FACTORS IMPACTING INNOVATIVE ACTIVITY IN WESTERN CANADIAN FOOD PROCESSING FIRMS

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By

Jillian Rae McDonald

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Department Head

Department of Agricultural Economics

University of Saskatchewan

Saskatoon, Saskatchewan

Canada, S7N 5A8

Abstract

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Supervisor: Dr. Mark Partridge

The industrial restructuring and technological change in the agriculture industry has limited employment opportunities and income in some rural areas. Food processing is one of the ways proposed to add value to agricultural products and provide employment opportunities and economic growth in rural areas. Worldwide, the food processing has seen growth stagnate, and the Canadian food processing industry is no exception. For long term growth, food processing firms must adopt innovation.

The development and implementation of innovation by food processing firms is influenced by six main factors. Access to product markets, labour availability and the network of a firm are some of the factors that influence innovation activity. The attributes of a firm, the competitive conditions a firm faces and the characteristics of the region where the firm locates also influence the innovation decisions of food processing firms. The innovation survey developed by the Canadian Agricultural Innovation Research Network, and distributed to 1,200 food processors in Western Canada links these factors and innovation activity.

Access to a large population and household amenities, such as skilled labour and business services, increases the probability that food processors in Western Canada will participate in innovation activities. Newer, larger firms and firms that could access knowledge spillover from other firms and industries also had a greater probability of introducing innovation. Therefore food processing firms within 400 km of an urban center are more likely to participate in innovative activities then food processing firms in remote rural areas.

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Chapter 1: Introduction

1.0 Introduction

Economic development of rural areas is of interest to academics and policy makers to reverse the decline of regions in rural Canada. The industrial restructuring and technological change in the agriculture industry in recent years has reduced the labour requirements, and limited employment opportunities and income, in some rural areas (Stabler, Olfert and Greuel 1996). One of the ways proposed to stabilize rural Canada and promote economic growth is to attract and maintain food processing plants in rural areas. Food manufacturing or processing plants can offer employment opportunities to the rural area and have the potential to increase area income through backward linkages to agriculture production (Henderson and McNamara 1997). But, is food processing the saviour for rural areas that it has been purported to be?

Little academic research has been done on the productivity and growth of food processors in Canada. Previous research on the Canadian food processing industry suggests that processing costs are 22 percent lower in the U.S. than in Canada (Chan-Kang, Buccola and Kerkvliet 1999). Research done in other parts of the world shows that the food processing industry internationally is under considerable stress, making it essential for firms to adopt innovation to remain competitive.

The adoption and implementation of innovation is therefore paramount for food processing firms to experience long run growth, both nationally and internationally. Some important questions immediately come to mind when considering innovation as a means for rural economic growth based on food processing. Does a rural location affect whether and how a firm innovates? That is, can a firm located in a rural area implement innovative activities, even at a distance from their market? While work has been done in both Europe and the United States, the Canadian food processing industry is relatively unknown to academic research.

Innovation in the food processing industry is an interesting process. Connor and Schiek (1997) and Rama (1996) contend that most innovations affecting the food industry originate outside of the food processing industry. The inter-sectoral dependence of the food processing industry for innovation was found in Europe (Rama 1996) and in the United States by Connor and Schiek (1997). Connor and Schiek (1997) in their study of the United States food processing industry indicate that, 75 percent of food processors' research and development (R&D) was contracted out. They found further evidence of the dependence of the food processing industry on inter-sectoral spillovers, in that only 0.4 percent of sales is spent on research and development activities in food processing. Beaulieu and Trant (2001) found that only 0.2 percent of company revenue in the Canadian food processing industry was spent on research and development. This is among the lowest ratios of any of the industry groups in manufacturing.

The dependence of the food processing industry on research and development from other sectors has implications for the location decisions of firms. There is evidence that suggests the spillover of knowledge has a limited geographic reach (Audretsch and Feldman 1996). This implies that location of a food processing firm is an important determinant of long term growth, as proximity to other sectors investing in innovation may affect the future competitiveness of firms. Therefore, the network and connections of firms to innovation sources is a key factor to examine.

The food processing industry has close linkages to raw agricultural commodities, produced largely in rural areas, and has a diverse nature with many products included in the industry mix. The majority of food processing firms in Western Canada are small firms with less than 20 employees, though large multinational corporations with hundreds of employees also exist. The small firms are often located in rural areas and can offer employment opportunities, as well as producing a variety of specialty products unique to that region. Large multinational corporations can generate significant employment opportunities and economic growth for a rural region because of their size.

The food processing industry is not quite as promising for rural areas as sometimes perceived. While some food processors have close linkages to raw agricultural commodities, transportation improvements mean it is easier to ship goods long distances. This reduces the need for food processors to locate close to their raw material supplies. Also, while food processing facilities may provide employment opportunities, there has been a general decline in the number of employees in the food processing industry and in the number of food processing firms in Canada due to structural changes in the industry (Beaulieu and Trant 2001). Experts believe that innovation is the key to the revitalization, growth and success of food processing in industrialized countries (Rama 1996).

Extensive literature exists on how innovation, in general, affects long term growth of firms and the competitiveness of those firms. In the food processing industry, work has been done on the origin of innovations in the industry, but little work has previously been done on the characteristics of firms that adopt these innovations. What are the factors that inhibit or promote the adoption of innovation within a food processing firm?

Are there specific characteristics that allow a firm to apply the innovation more successfully than its neighbour that produces the same good? Does innovation happen in the same way at the same rate in rural firms as it does in urban firms? Do qualified labour shortages inhibit the adoption of innovation? If innovation is the key to the revitalization and growth of the food processing industry, then closer study of firms in the food processing industry is required to understand the adoption of innovation in the industry.

1.1 Purpose and Objectives

Little work has been done on the relationship between innovation and the development of the food processing industry in Canada. To further the understanding of this relationship, this thesis examines the factors that affect innovative activities of food processing firms in Western Canada. The research also examines if there are locational advantages for firms in urban or rural regions.

This study will provide an in-depth examination of innovation in the food processing industry in Western Canada. A primary contribution is the geo-coded innovation survey of food processors in Western Canada that was developed by the Canadian Agriculture Innovation Research Network in the spring of 2005. This survey was distributed to approximately 1,200 food processors in British Columbia, Alberta, Saskatchewan and Manitoba in the autumn of 2005. No other study of innovation activities of food processors in Western Canada has previously been done, in particular one that links firm characteristics, market access and regional attributes with innovation. This data set will be of considerable value to future research of food processors and their innovation activities.

1.2 Hypothesis

The null hypothesis of this thesis is that the probability of food processing firms participating in innovation activities will decrease with greater access to markets, and will not depend on the region where they are located. The data set from the innovation survey, will be used to determine the characteristics of food processing firms participating in innovation activities in Western Canada.

More specific hypotheses are that the probability of food processing firms participating in innovative activities will not be affected by whether the firms have an extensive network of suppliers and export their products outside of their local market.

1.3 Organization of the Thesis

This thesis is composed of seven chapters. An overview of the food processing industry in Canada, and the conditions specific to each of the western provinces is provided in Chapter 2. A review of the relevant literature is included in Chapter 3. The theoretical framework that is used to analyze the problem follows in Chapter 4. The methodologies of the thesis, including the different empirical models for the data analysis, are described in Chapter 5. The results of the hypotheses tests are presented in Chapter 6; conclusions follow in Chapter 7.

Chapter 2: Industry Overview

2.0 Introduction

This chapter gives a brief overview of the Canadian food processing industry. The chapter begins with an outline of the food processing industry in Canada, and then follows with a description of some of the changes that have occurred in the industry in the past two decades. The chapter goes on to give further details of the food processing industry in each individual province included in this investigation.

2.1 The Canadian Food Processing Industry

Food processing seems to be a promising industry to attract to rural areas. It is the third largest manufacturing industry in Canada, representing 1.9 percent of Gross Domestic Product (GDP) (Beaulieu and Trant 2001), employing 238 000 people in 2001 (Statistics Canada 2004). The food processing industry accounts for 12 percent of all manufacturing employment in Canada. Specifically, in Western Canada, the industry plays a large role in manufacturing, and accounts for over 20 percent of all manufacturing shipments (Beaulieu and Trant 2001). Overall, the Canadian food processing industry is a mature industry with modest plant sizes, and moderate growth over recent years (Beaulieu and Trant 2001; Baldwin, Sabourin and Smith 2003).

Canada has seen significant growth in exports of processed food since 1992. In the ten years between 1992 and 2001, food processors increased exports by 12 percent per year (Statistics Canada 2004). There have been increased exports to Japan, China and South-East Asia. The United States remains the largest market for Canadian exporters, purchasing a little over half of Canada's total processed food exports. However, the Canadian share of the U.S. food processing market declined between 1988 and 1994 (Beaulieu and Trant 2001). Further declines should be expected because new labeling and import policies on products originating outside of the U.S are likely to act as a barrier to trade.

Statistics Canada (2004) reports that food processors in Canada, on average, add about 32 percent to the value of their products. Food processors add value to a product by modifying the raw good and selling the processed product. An example of this is a bakery which combines the raw products of flour, sugar, salt, yeast and vegetable oil to produce baked goods. Food processors have increased the value added to their products by about 4 percent per year between 1992 and 2001. Other manufacturing industries have added value to their products at a rate of 8 percent per year during the same period. During this period meat processing and sugar and confectionary manufactures were the best performers with the value added of their products increasing each year by 5.3 percent and 5.5 percent respectively (Statistics Canada 2004). The value added lag relative to other manufacturing industries is a concerning for the food processing industry.

The food processing industry has seen great structural change during the last two decades. Between 1988 and 1994, the number of food processing plants in Canada declined by 11 percent, while the size and average shipments of the remaining plants increased. During this same period there was also a decline in employment. Employment numbers peaked in 1988, and have been declining ever since due to labour saving technology (Beaulieu and Trant 2001).

The Canadian food processing industry is a mature competitive industry consisting of more than 3000 establishments (Baldwin et. al 2003). Between 1988 and 1997, there were considerable market share changes in the food processing industry as some firms captured market share from others. During this time period, almost half of the Canadian food processing firms reported an increase in market share (Baldwin et. al 2003). On average 32 percent of market share was transferred between firms. Almost 20 percent of that market share was transferred to established firms gaining market share, while new entrants into the market gained 12 percent of the market share. Established firms in the market lost 13 percentage points, while exits from the market accounted for the remaining 19 percent of market share transfer (Baldwin et. al 2003).

2.2 British Columbia Food Processing Industry

The food processing industry in British Columbia is very diverse. With products ranging from fresh fruits and vegetables, to wine, frozen shrimp and smoked salmon jerky, the food processing industry encompasses a number of different products. The industry contributed just over $2.2 billion to the provincial GDP and is the third largest manufacturing industry in the province. The majority of the food processing firms in the province are small to medium sized businesses and on average have less than 50 employees (Government of British Columbia 2006).

The B.C. industry displays a high degree of clustering. Just over half of all food processing firms are located in the greater Vancouver area and Fraser Valley, with another 30 percent of firms located in the Okanagan Valley and the coastal regions. (Government of British Columbia, 2006). There are approximately 1100 food processors operating in the province.

The British Columbia (BC) Food Processors Association is a non-profit organization with strong ties to the provincial government. This association is in a re-building phase, and currently has close connections to the Ministry of Agriculture and Lands. Numerous small associations and councils represent the many different products that are produced in BC. The BC Food Processors Association is currently attempting to represent all food processors under one umbrella organization.

2.3 Alberta Food Processing Industry

The Alberta food processing industry is a mix of large and small companies. While the number of firms in the province is much less than BC, there are large multi-national firms in the province, particularly in the meat sector, who employ hundreds of people.

Alberta has approximately 325 active food processors within the province. Of Canada's $26 billion of agri-food exports, Alberta accounts for almost 25 percent of that total. Alberta is the second largest agri-food exporter behind Ontario (Alberta Economic Development 2006).

The food processing industry is the largest manufacturing industry in Alberta. In 2002, it employed just over 28,000 people. The food processing industry accounted for 24 percent, or $9.8 billion worth of manufactured goods. Almost two thirds of the food processing industry in Alberta is concentrated in two segments, meat and meat products, and dairy, with the former accounting for half of the food processing manufacturing. Alberta is the largest beef processor in Canada, accounting for 66.8 percent of the cattle slaughter in Canada in 2004. It has six federally inspected processing facilities, with capacity to slaughter 50,000 head per week. (Alberta Economic Development 2006).

Alberta promotes its business friendly policies and location to attract food processors to the province. It cites its strategic location to the West Coast of Canada and the U.S. and the Pacific Rim countries, as well as the well developed road system as desirable attributes for food processing firms. Alberta proposes that the combination of location to markets and access to reasonable priced raw commodities will attract food processors to the province (Alberta Economic Development 2006).

2.4 Saskatchewan Food Processing Industry

The Saskatchewan food processing industry is characterized by small independent firms. It is estimated that there are approximately 160 establishments in the province. In 2001, these firms employed 5,684 workers and contributed $779 million to the provincial GDP. Based on their respective employment, the top three sectors in Saskatchewan are meat and meat products, grain and oilseed milling and animal food manufacturers. The grain and oilseed milling sector directly contributed $444 million to the provincial economy, while the meat and meat products sector contributed $381 million. The contributions of the other sectors were relatively small (Kulshreshtha and Thompson 2005).

The food processing industry is one of the largest manufacturing industries in the province, accounting for 20 percent of the province’s total manufacturing output (Government of Saskatchewan 2006). The Saskatchewan government is interested in promoting further development of food processing in the province and offers a number of incentive programs for food processors, including a 15 percent rebate program on construction or expansion costs of federally registered meat processing facilities (Saskatchewan Agriculture and Food 2006).

The Saskatchewan Food Processors Association is an umbrella organization that represents almost all of the food processors in the province. This organization is in place to help firms market their products within the province and to other markets. The organization operates outlets where Saskatchewan made products are sold to provide the small processors in the province an opportunity to market their products (Saskatchewan Food Processors Association 2006).

2.5 Manitoba Food Processing Industry

There are approximately 200 food processing firms located in Manitoba. These firms employ approximately 8,500 people. Most of the firms in Manitoba are small or medium sized enterprises, representing a variety of sectors, including meat and meats products and vegetable processing (Manitoba Industry, Economic Development and Mines 2006).

The food processing industry is the largest manufacturing industry in Manitoba accounting for 25 percent of the manufacturing shipments in the province. These shipments total approximately $3.1 billion. The main sector in the industry is meat and meat products. The province is home to four federally inspected hog processing plants, and has the largest value added egg processing plant in Canada. The province also has three large potato processing facilities, making Manitoba the second largest potato producing province in Canada (Manitoba Industry, Economic Development and Mines 2006).

The Manitoba Food Processors Association is a strong, industry run, non-profit organization that represents almost all food processors in Manitoba. The goal of the association is to promote Manitoba-made products to domestic and international markets and provide education and training to its members. This organization also serves as a communication link between its members and government (Manitoba Food Processors Association 2006).

2.6 Chapter Summary

An overview of the Canadian food processing industry is provided in this chapter. Details of the food processing industry in each province in Western Canada are also provided. Each region has sectors within the industry that are decidedly important to that province. This chapter provides some insight to the contribution the food processing industry makes to the Canadian economy, and to the provincial economies of BC, Alberta, Saskatchewan and Manitoba.

Chapter 3: Literature Review

3.0 Introduction

There are several areas of literature that provide the theory that is required to understand why firms adopt or participate in innovation and research and development activities. Literature from a variety of economic disciplines is important to this thesis, including economic growth, knowledge spillover and industry specific literature. Literature important to the theoretical framework, analytical framework and methodology chapters are discussed here.

3.1 Defining Innovation and Its Effect on Growth

This thesis focuses on the concept of innovation, a vague concept that is difficult to define. With innovation such a central theme in this research, it is important for readers to define innovation and its effects on firm growth.

3.1.1 Innovation Defined

North and Smallbone (2000) define two key issues to consider when discussing innovation. First, the question of whether the term innovation should be used to solely describe developments that are new within the industry, or whether changes new to the firm itself should also be termed innovation, regardless with how they compare to other firms in the industry. Some of the early work done on innovation tends to adopt the view that innovation involves radical change resulting in the development of a new marketable product or process. This definition would not include the creative processes implemented within a business that increase the efficiency of production or improve company management (North and Smallbone 2000).

Some of the more recent work on innovation views it as an attempt to create competitive advantage by creating new or better ways of competing in an industry. In this sense, innovation is then a way to a higher order of competitiveness by reducing labour costs, using cheaper inputs, or improving production processes. This definition of innovation appears rather uninteresting, and does not include the introduction of radical innovative products into the market (North and Smallbone 2000).

A more balanced approach to defining innovation is to include improvement in technology for both product and process aspects of the business. This encompassing approach recognizes the introduction of radical innovation into the market or firm, as well as more mundane innovation introductions. This was the definition applied to innovation for this investigation. *Product innovation* was defined as the introduction of a new, or significantly improved good or service, where the innovation may be new to the industry, market or the business. *Process innovation* was defined as the implementation of a new or significantly improved production process, distribution method or support activity for the goods or services of the business. The innovation may be new to the industry, market or the business.

3.1.2 Innovation and Long Run Growth

Romer (1986) provides an extensive growth model where the primary driver of long run growth is the accumulation of knowledge by forward-looking, profit maximizing firms. Romer uses endogenous technical change in the model and assumes knowledge is the product of research technology and exhibits diminishing marginal returns. That is to say, given a stock of knowledge, at a given point in time, doubling the inputs into research will not double the amount of knowledge produced. This new knowledge produced by the firm suggests a natural externality will occur because the knowledge can not be kept perfectly secret. Patents are a useful method of protecting this knowledge, but do not offer perfect protection. Therefore, other firms have the potential to benefit from the new technology.

As long as the costs of acquiring the knowledge are less than the potential gains, it is not optimal for the firm to stop at a steady state where knowledge is held constant. It is always to the benefit of the firm to obtain new knowledge, and benefit from the growth that occurs from this knowledge. Romer suggests that new knowledge will grow without bounds, as firms will continually want to build on their previous knowledge.

Parisi (2004) provides empirical work to support Romer's long run growth model. Parisi (2004) investigated the introduction of innovations into the production function of firms to evaluate the contribution of innovation to growth. This investigation found that innovations pushed productivity growth up 12-18 percent in the long run and 7.3 percent in the short run. These results are consistent with Romer's theoretical model.

3.2 Innovation and Firm Survival

Schumpeter's (1942) ground breaking work argued that innovation plays a vital role in the survival of a firm, not only for new firms entering a market, but for established firms that dominate a market. In combination with previous work presented by Romer

(1986) and Parisi (2004), it would seem obvious that firms would participate in innovation activities to experience long run growth. While long run growth is a motivating factor for introducing new knowledge, investigation into other motivating factors, and firm characteristics that contribute to innovative activity should be considered.

Organizations need innovation to maintain their competitive position and extend their survival time. Cefis and Marsili (2004) completed an extensive investigation of 3,000 firms in the Netherlands. The authors found the expected survival time of an innovative firm (product or process innovation) to be about 11 percent higher than that of a non-innovative firm. Cefis and Marsili estimated their model on specific categories of firms within the study and found that survival among young and small firms increases up to 23 percent with the introduction of innovation.

By performing this analysis on specific groups, they found another interesting result. They found that there is a distinct difference in firm survival between product and process innovation. Firms that introduce new products do not necessarily have a higher chance of survival than non-innovators. However, the introduction of process innovation significantly increased the likelihood of survival.

3.3 Firm Characteristics and Innovation

One of the most extensively researched topics with respect with innovation and long run growth, is the effect firm size has on the adoption or introduction of innovation. Rothwell and Zegveld (1982) discuss the advantages large firms have in the innovation process. They argue that large sized firms have the resources, financial and human, as well as the external communication and economies of scale to undertake research and development and introduce innovations.

Furthering this research, Acs and Audretsch (1987) find that large firms in concentrated industries with high barriers to entry display a high degree of innovation when compared to small firms in the same industry. Cohen (1995) argues that large firms have a greater propensity to innovate because they have greater access to financing, can spread the fixed cost of innovation over a larger volume of sales, and may experience economies of scope. Acs and Audretsch (1988) also find that the extent to which an industry is comprised of large firms is positively related to the number of innovations within the industry.

Rothwell and Zegveld (1982) contend that it is not only large firms that introduce innovation. Small and medium sized firms have the ability to introduce innovations, and may develop innovations that are more directed at a specific market. Grunert et. al (1997) present results consistent with this work and show that small firms have behavioural advantages over large firms allowing them to react to market changes more quickly, and permitting them to develop and implement innovation at a faster rate than large firms.

Cohen (1995) supports these findings, but suggests the role of firm size in innovation adoption, while important, has been exaggerated due to underlying industry conditions. Acs and Audretsch (1988) concur with this idea and suggest that innovative activity in large and small firms responds to different technological and economic environmental conditions. Therefore, the literature on firm size and its effect on innovative activity is somewhat ambiguous.

The economic and market conditions experienced by a firm can limit the potential growth that could be achieved through its innovation activities. It has been proposed that firms active in markets with a low degree of competition will be more innovative as they can appropriate the returns from the innovation they adopt (Baldwin and Sabourin 1999). Others have proposed that gains from innovation at the margin are larger in a competitive industry than under monopoly conditions (Cohen 1995).

Cohen (1995) points out that the literature on firm-specific characteristics that promote, develop and implement innovation is very weak. Rothwell (1994) suggests a number of firm-specific characteristics that are common among successful innovators. The long term commitment of management to innovation, the flexibility and responsiveness of the firm, and the creation of innovation-accepting, entrepreneurship-minded individuals within the firm all contribute to a successful the innovation process. Rothwell (1994) maintains to successfully implement innovation the new products, the skills, and the resources of the company going into the production of the product must be 'right' to serve their market. Grunert et al. (1997) find that both R&D and market orientation, as well as the way they are coordinated, are major determinants of innovation in the food processing industry.

Cooper and Kleinschmidt (1987) looked specifically at the success factors in product innovation. They report five components that are common for firms with successful product innovations. Included in these components is that new product success is multidimensional. Financial performance, opportunity window and market impacts are also influential in determining if a product innovation is successful. Another component to successful product innovation is having a well-defined project plan prior to development of the product.

3.4 Acquiring Innovation: Knowledge Spillovers

There has been considerable interest in knowledge spillovers and innovative activity of firms. Romer (1986) and Krugman (1991) among others, have studied the spillovers of knowledge among firms and agents to generate economic growth. The idea that innovation and knowledge contributes to economic growth and that spillovers of knowledge exist among firms and agents is an essential part of this thesis and to the food processing industry.

Early work by Rothwell and Zegveld (1982) provides some insight into the relationship between innovation and knowledge spillovers. In a study of regional economics and innovation in the United Kingdom, they found evidence that there is limited mobility of new innovations between regions, but innovation is mobile within the region. The authors also suggest that the number and nature of innovations in a region depend on the technological requirements of the local markets.

In a more recent study, Bottazzi and Peri (2003) find spillovers are very localized and exist only within a distance of 300 km. The authors found that if the research and development spending in a region was doubled, the increase in innovations would increase only 2-3 percent in the regions within 300 km, while innovation in the region itself would increase 80-90 percent. As is discussed later, this result is very important to the food processing industry.

Audretsch and Feldman (1996) suggest that industries where knowledge spillovers play an important role in innovation activity, will exhibit a high degree of geographic concentration. In their investigation, they found that food and beverage manufacturing was one of the industries displaying the highest geographic concentration of manufacturing, yet was not among the manufacturing industries exhibiting the highest propensity for innovative activity.

While industries may tend to cluster geographically, knowledge spillover does not just occur within an industry. Knowledge spillovers can occur between industries. Glaser et. al (1992) present evidence that suggests knowledge spillovers within an industry are less important than the spillovers that occur across industries. Cooke and Morgan (1994) support these findings. They argue that innovation is an increasingly collaborative process, and innovation is strongest where networks exist to link institutions and firms. The networks of private and public organizations are an essential part of innovation infrastructure in a successful economic region.

3.5 Innovation and the Food Processing Industry

While some work has previously been done on innovation and growth in the Canadian food processing sector, the literature is not very extensive. Prior work has been done on U.S. food manufacturing with respect to firms' location decisions and growth. Goetz (1997) and Henderson and McNamara (1997) identified the economic determinants of food manufacturing establishment growth for states and counties in the U.S. While results were not consistent across counties, Goetz (1997) found that lower labour costs, higher education attainment levels and larger population were associated with statistically significant growth at the state level.

Henderson and McNamara (1997) examined local and regional attributes influencing local food processing growth in the U.S. corn belt. They concluded that remote rural areas are at a disadvantage to attract food processing establishments, mainly due to lack of market access. Rural areas in proximity to an urban area offer access to business services, have an existing manufacturing base, and have access to a large consumer group.

Neither the work by Goetz (1997) or Henderson and McNamara (1997) considered the influence innovation would have on growth in the food processing industry, or on its location decisions. With the previous section highlighting the importance of innovation in economic growth, it is essential to analyze research on the effects innovation has on the long term growth of the food processing industry, and what factors stimulate innovative activity within the food processing industry.

Innovation and research and development (R&D) in the food processing industry is closely linked to innovation and R&D in sectors such as primary agriculture and other types of manufacturing. Rama (1996) studied innovation in the international food and beverage industry and found that most firms depended on suppliers, rather than on an internal effort, to provide them with technological innovation. Gopinath and Roe (2000) also suggest the vertical linkages the food processing industry has with primary agriculture and manufacturing contribute to external spillovers of R&D. This creates a market failure, and decreases the incentive for private food processing firms to invest resources in internal R&D.

The food processing industry's low expenditure on internal research and development and its reliance on other industries for innovation, has implications for its innovation activities. If the ability to receive knowledge is limited to being located near a knowledge source, then geographic concentration of industries will occur. Audretsch and Feldman (1996) find that industries where knowledge spillovers are the most prevalent have a greater degree of geographic clustering of their innovative activity than industries where knowledge externalities are less important. Audretsch and Feldman (1996) did not specifically focus on the food processing industry, but they did find that the food and beverage industry had a high degree of geographic concentration.

In addition to the geographical considerations, the adoption and success of product and process innovation in the food processing industry requires other factors. Grunert et al. (1997) argue that successful innovation in the food industry is difficult because the tastes and habit for food are part of the cultural heritage and change slowly. Investment in innovation or adoption of innovative processes or products, does not ensure success or survival in the food processing industry.

Specific research has been done on innovative activities in the Canadian food processing industry. Baldwin and Sabourin (1999) find that in the Canadian food processing sector, firms have a 53 percent probability of participating in innovation activities, if they do not have a research and development unit within their firm. Firms with an internal research and development unit have over an 80 percent probability of participating in innovation.

Baldwin and Sabourin (1999) found evidence that increasing competition within the food processing industry increased innovative activity. Larger firm size and foreign controlled plants also increased the probability of a firm introducing an innovation. Foreign ownership was especially important if the firm introduced process innovations.

In further work by Baldwin, Sabourin and Smith (2003), the authors investigate the characteristics of Canadian firms that adopt innovation and how the characteristics affect growth. The empirical work suggests firms that incorporated innovation into their activities saw productivity grow more quickly and their market share increase. The firms that adopted innovation had business practices that promoted innovation, including a human resource strategy that continuously improved the skill of its workforce through training and recruitment. This earlier work on innovation in the food processing industry did not link geographic location with innovation, as this thesis does.

3.6 Conclusion

This chapter examined several areas of economic literature that are relevant to this thesis. The chapter started with a definition of innovation and how it relates to long term growth. The effect innovation has on long term growth and firm survival follows. The next section outlined the characteristics of firms that adopt innovation, followed by a review of how firms acquire innovation through knowledge spillovers. The chapter concludes with a review of the literature of innovation in the food processing industry.

Chapter 4: Theoretical Framework

4.0 Introduction

The purpose of this chapter is to present a theoretical framework for investigating why firms adopt innovation and participate in research and development activities. Theories on knowledge spillovers between firms will also be presented to analyze if there is a location advantage between urban and rural firms. This framework is used to develop some hypotheses and to construct a methodology to test for attributes that influence a food processing firm's decision to adopt innovation.

The theoretical framework chapter proceeds as follows. The effect innovation has on long term growth and productivity is first described. The motivation for firms to adapt innovation is briefly discussed. Then the factors affecting the adoption of innovation by food processing firms is described, with an in depth description for each of the factors. Understanding these factors is crucial to the empirical analysis of this thesis.

4.1 Innovation and Growth

The literature on innovation and its affect on long term growth and competitiveness is considerable. From the seminal work by Schumpeter (1942) and further work by Romer (1986), the effect innovation has on long term growth is undeniable. Griliches (1995) provides a basis for analyzing the contribution research and development makes to economic growth. The starting point is a production function, which can be represented by the following equation:

$$Y = f\,[X, K(INN), \mu] \tag{4.1}$$

Where Y is a measure of the output at the firm or industry level, X is a vector of standard economic inputs, such as labour costs, equipment maintenance and energy use. The vector X also includes innovation costs. The vector K is a measure of the current state of technical knowledge, determined in part by current and past expenditures on research and development. The vector INN represents the adoption of innovation by firms and μ represents all other unmeasured determinants of output and productivity including innovation spillovers from nearby firms.

Equation 4.2 describes the relationship between K, the current state of technical knowledge, and INN, the adoption of innovation by firms.

$$K = f\,(INN) \text{ where } f' > 0,\ Y_K' > 0,\ X_K' > 0 \tag{4.2}$$

The decision to innovate or adopt innovative technology is motivated by the profit growth that can be achieved from the innovation.

$$\prod = PY - c(X) - r(K) \tag{4.3}$$

Equation (4.3) is the profit function for a firm, where profit (∏) is equal to the revenue of the firm (PY), subtracting the cost of the economic inputs ($c(X)$), the cost of the technical knowledge ($r(K)$), and the cost of innovation ($c(INN)$). Assuming that firms are maximizing profits, this objective function drives firm activity. Firms will participate in activities that increase profits, therefore the expected costs of adopting innovation, cannot be greater than the expected revenue that the innovation will generate.

Equation 4.4 shows the first order conditions of the profit function for innovation:

$$\frac{\partial \Pi}{\partial INN} = PY_{INN} - c_X^{'} \frac{\partial X}{\partial INN} - r_K^{'} \frac{\partial K}{\partial INN} = 0 \qquad (4.4)$$

Equation 4.4 could be re-arranged and expressed by equation 4.5:

$$MRP_{INN} = MC_{INN} \qquad (4.5)$$

Where MRP_{INN} is the marginal revenue product of innovation and is equal to PY_{INN}. The marginal cost of innovation is MC_{INN}, is equal to the sum of $c_X^{'} \frac{\partial X}{\partial INN}$ and $r_K^{'} \frac{\partial K}{\partial INN}$. Therefore the marginal revenue product of innovation (MRP_{INN}) is equal to the marginal cost of innovation (MC_{INN}) at equilibrium, and firms will continue to participate in innovation activities until this equilibrium point is reached.

As shown in equations 4.4 and 4.5, factors that cause the marginal revenue product of innovation to increase will cause innovation to increase. Another way of stating this relationship is that factors that cause the marginal cost of innovation to decrease, will increase innovation activities.

4.2 Firm Adoption of Innovation

Theoretically, if a firm sees the opportunity to experience profit by innovating, firms will adopt the innovation or participate in the R&D to create the innovation. As shown in equation 4.5, knowledge is a function of innovation.

Cohen (1995) and Grunert et. al (1997) show many factors influence whether a firm will innovate.

$$INN = f\,[MKT, LBR, NET, REG, FRM, COMP] \qquad (4.6)$$

Equation 4.6 represents the relationship presented in the literature by Cohen (1995) and Grunert et. al (1997). The decision to innovate or adopt innovative technology (*INN*), is a function of market access (*MKT*), labour skill and accessibility (*LBR*), and the network of suppliers, clients and competitors to a firm (*NET*). Also, the characteristics of the region, including the available infrastructure, of where the firm is located (*REG*), firm attributes (*FRM*) such as firm size and years of operation, and the overall competitive conditions of a firm (*COMP*) will influence the firm's decision to innovate.

The above equation (4.6) can be closely linked to the profit function, equation (4.3). The variables that influence innovation, also contribute to the costs of a firm. Examples of this connection include labour (LBR). Employing skilled labour increases the probability that firms will participate in innovative activities, and skilled labour is generally paid a higher wage than unskilled labour.

The region where a firm locates (REG) also affects the profit function of a firm. Different regions will have different land costs associated with them. Land outside major cities can generally be obtained at a lower cost, but this may increase the transportation costs for a firm to get their goods to market.

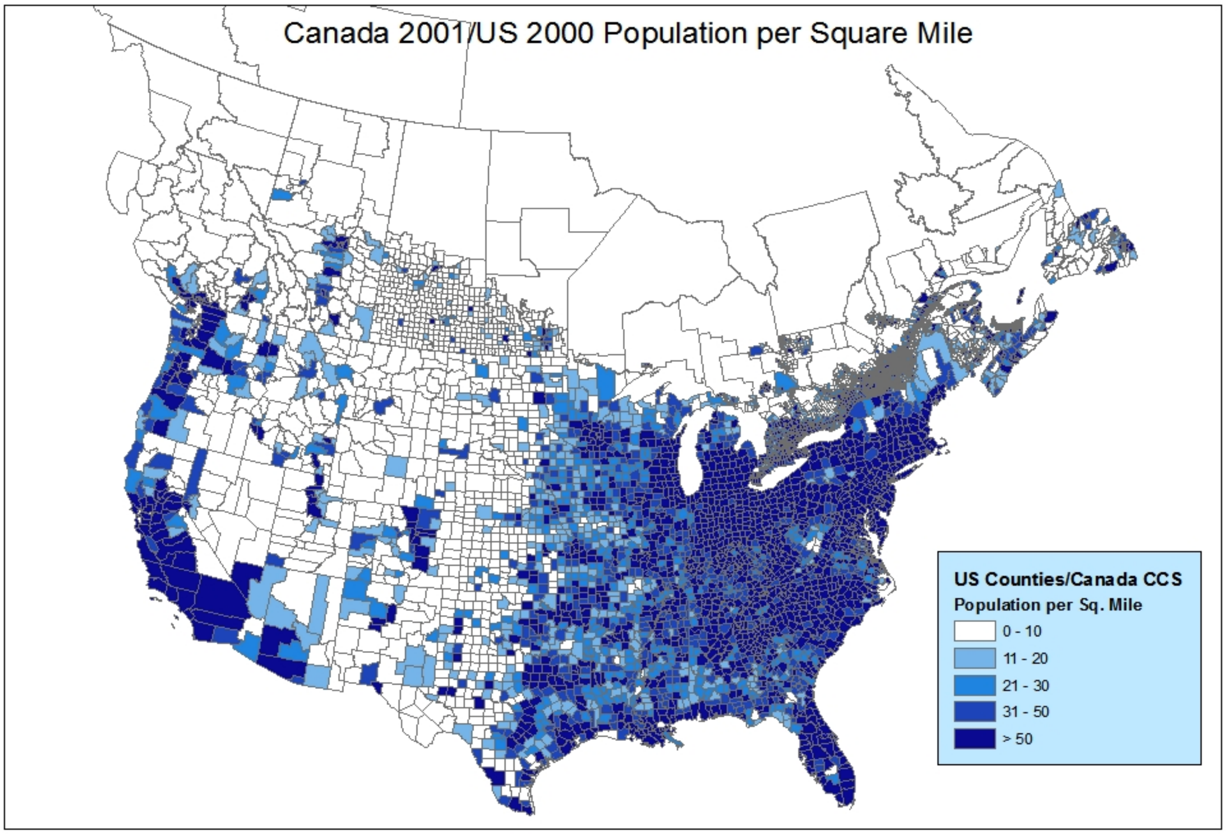
The development and implementation of innovation is influenced by many factors that affect the profit function of a firm. If the costs of innovation are too high, firms will not participate in innovation activities. If there is profit to be made from introducing innovation (assuming the firm is profit maximizing), firms will continue to participate in innovation activities, until equilibrium is achieved between marginal revenue and marginal cost (equation 4.5).

4.2.1 Market Access

Input and final product markets influence innovation decisions and growth in the food processing industry. The size of the final product market determines current and future demand for a product (Glaeser et. al 1992). A large population offers more opportunities for firms to sell their final product, and also to purchase inputs to make their product. A large population provides a large labour pool, with a lower probability of a labour shortage (Krugman 1991). With respect to market size, urban areas appear to have an advantage over rural areas, as urban areas tend to have greater population and greater income (Henderson and McNamara 1997).

The remoteness of a firm is another market factor to consider. A firm located in a remote rural region may find it difficult to be competitive and experience long run growth as benefits from agglomeration and having access to a large market cannot be realized (North and Smallbone 2000). On the other hand if a firm specializes, it may be maximizing profits by locating away from a densely populated area and capitalize on lower land rent and decreased congestion costs (Henderson 2003).

Figure 4.1: Population Density in North America



Source: Canada Rural Economy Research Lab (C-RERL)

Figure 4.1 shows the population density of North America in 2000/2001, and clearly illustrates the situation experienced in Western Canada. As shown in this map, many regions of Western Canada are not located close to a large population, therefore limiting their market access. However, as transportation and communication technology improve, the remoteness challenges to a food processing firm, may decrease in importance as fixed cost minimization becomes the primary cost concern (Kilkenny

1998). This may benefit rural areas as they are closer to inputs necessary for food processing.

Distance to market or a large population will also affect the knowledge spillovers experienced by a firm. The food processing industry exhibits a high degree of manufacturing clustering, yet is not among the industries exhibiting the highest propensity for clustering for innovative activity (Audretsch and Feldman 1996). However, Rama (1996) and Gopinath and Roe (2000) found that food processing is heavily dependent on innovation that has been adopted from other industries.

Considering the above findings, food processors that adopt innovation will locate near an urban center where they can reap benefits from a manufacturing cluster, and also receive knowledge spillovers from other industries and firms participating in innovation activities (Glaeser et. al 1992). This is consistent with findings of Henderson and McNamara (1997) who provide evidence that food processors in the U.S. that experience the largest growth were located within a reasonable proximity to an urban center.

4.2.2 Labour Market

Labour availability can be a limitation to a firm's innovation activities. A large labour pool offers firms a diverse and flexible labour pool that reduces recruitment and retention costs for firms (Krugman 1991). An educated work force increases productivity for firms, leading to higher output per unit cost (Henderson and McNamara 1997). Urban areas have the potential to offer a larger, skilled labour pool, yet rural areas tend to have lower labour and land costs. In theory, having access to a skilled labour force will increase the probability that a food processing firm will participate in innovation activities.

4.2.3 Network of Firm

The network of a food processing firm plays a large role in the innovation activities of the firm. There has been evidence presented by Rama (1996) and Gopinath and Roe (2000) that there is a significant spillover of innovation from other industries into the food processing industry. Food processing firms will adopt innovation from other industries, competitors, clients and suppliers; therefore including these relationships in the framework is vitally important to the analysis. In addition to clients, suppliers and competitors of the firm, the network of a food processing firm also includes agents such as government organizations, industry organizations and universities or higher education institutes.

4.2.4 Regional Characteristics

Regional characteristics include many factors such as tax policies, expenditure patterns of local governments, overall business environment, and the infrastructure of the region where a food processing firm locates. Some regions may have a political environment that supports the adoption of innovation through government programs, tax incentives or outreach extension programs from public institutions such as universities. These factors may contribute to a higher level of innovation in food processing firms in certain regions.

Infrastructure is the set of installations and facilities that support the community and enhance firm profitability and business activity (Henderson and McNamara 1997). Transportation infrastructure such as highways, railroads and airports improve firms' access to markets. Access to good roads and reliable transportation for products will lower transportation costs, and potentially increase the access to innovation for food processing firms.

4.2.5 Firm Attributes

Attributes such as the size, revenue and ownership structure of the firm have proven to be important in the adoption of innovation practices (Cohen 1995). Extensive literature exists on how the size of a firm affects innovation activities, yet literature on the effects of other firm attributes on innovation is somewhat limited. Industry structure has been a key factor described in previous literature, yet the empirical evidence to measure its impact on firm adoption of innovation is sparse and inconclusive. For this thesis, the impact of industry structure is captured in firm attributes by including the ownership structure of the firm, and in the vector of competitive conditions.

Acs and Audretsch (1987) find that large firms in concentrated industries with high barriers to entry display a high degree of innovation when compared to small firms in the same industry. Acs and Audretsch (1987) also found that smaller firms are more innovative in industries that experience a low degree of concentration and are less mature. It is argued that large firms have a greater propensity to innovate because they have greater access to financing, can spread the fixed cost of innovation over a larger volume of sales, and may experience economies of scope (Cohen 1995). Grunert et. al

(1997) argue that small firms have behavioural advantages over large firms allowing them to react to market changes more quickly, allowing them to develop and implement innovation at a faster rate than large firms. The Canadian food processing is a mature industry, yet is characterized by a large number of small firms, so the impact of firm size on innovation practices in the industry is unclear.

The revenue and cash flow of a firm, and its effect on innovation adoption, is a controversial firm characteristic in innovation literature. Some studies have found that better cash flow is associated with higher levels of research and development activities, while other studies found that firms invest more in innovation when performance falls below a threshold level (Cohen 1995). While the effect of firm revenue on its innovation activities is unclear, it is still an important factor to include in the analysis.

Previous literature does not directly discuss the age of a firm and how it affects innovative activities. Work by Cohen (1995) briefly mentions that firms entering a market may be more likely to introduce innovations to gain market share and be competitive in the market. One reason for the lack of previous work on the age of the firm may be because past work has stressed how industry concentration affects innovative activities.

Schumpeter (1942) recognized that firms required an incentive to innovate, therefore firms operating in a monopolistic market would be more likely to innovate because the rents from the innovation can be solely captured by the firm. Cohen (1995) summarize literature that disputes this view, by providing empirical research that shows that firms operating in a competitive market will be more likely to introduce innovation in order to remain competitive in the market. While the research is conflicting, this debate could potentially explain why little work has been done on firm age. Both sides of the debate seem to assume firms operating in these market conditions are established firms, and that market structure will determine how long a firm survives.

The firm's investment in research and development (R&D) and innovative activities is an important factor. Grunert et. al (1997) point out that no clear relationship exists between spending on R&D and the level of innovative activity in food processing firms. Research presented by Grunert et. al (1997) showed that the best performing companies in the food processing industry were technologically advanced, but direct spending on research and development was low, suggesting that technology was adapted from outside the company. Alternatively, Scherer and Ross (1990) noted that increased spending on R&D, may lead to new products being developed and the enhancement of firm profits. The causality of this relationship between firm investment in R&D and the innovative activity is unclear.

4.2.6 Competitive Conditions

Previous literature proposes that the industry structure and competitive conditions a food processing firm faces are important factors in their innovation decisions. It has been proposed that firms active in markets with a low degree of competition will be more innovative as they can appropriate the returns from the innovation they adopted (Baldwin and Sabourin 1999). Others have proposed that gains from innovation at the margin are larger in a competitive industry than under monopoly conditions (Cohen 1995). The industry structure and its impact on innovation activities is difficult to measure, possibly contributing to these conflicting views. While the direction of influence is clear, these findings suggest that the competition a firm experiences will influence its innovation activities. How it affects the innovation activities of Canadian food processing firms competing in a mature, competitive industry is unclear.

In addition to the industry structure within which a firm operates, the competitive conditions of a firm also include the market orientation of the firm. Grunert et. al (1997) provide evidence that firms are more likely to introduce innovation if they systematically monitor market developments of their clients and competitors. This ensures that the innovations that are implemented correspond to market needs. The market orientation of a firm is a difficult concept to measure empirically. Grunert et. al (1997) suggest that one way to determine the market orientation of the firm, is to have firms self identify their market orientation. This is a rudimentary way of determining market orientation, but few other options exist to measure this important aspect of innovation activity in firms.

4.3 Chapter Summary

The purpose of this chapter was to develop a theoretical framework in which to analyze the factors that influence innovation activities in the food processing industry. It is assumed that firms are profit maximizing and will participate in innovation activities if there is a likelihood of increased profits. The profit function includes the cost of developing or purchasing the innovation.

Previous work has identified six main factors that influence innovation activities of firms. These six main factors are market access, labour market access, the network of a firm, the regional characteristics of where a firm is located, the internal attributes of the firm, and the competitive conditions of the market in which the firm operates. It is predicted that market access will have the greatest impact on a food processing firms participation in innovative activities.

The next chapter describes the methodology of the analysis. The six factors described in this chapter will each have a number of different variables used to measure their impact on innovation activities in food processing firms.

Chapter 5: Methodology

5.0 Introduction

The methods used to test the null hypothesis are outlined in this chapter. The null hypothesis is that the probability of food processing firms participating in innovation activities will decrease with greater access to markets, and will not depend on the region where they are located. The construction and distribution of the innovation survey is first described. The econometric approach to determine the effect of explanatory variables on innovation activities is then provided. The chapter concludes with a description of each econometric approach applied to the data.

5.1 The Innovation Survey

Innovation in the Canadian food processing industry is not well understood. In 1998, Statistics Canada conducted the *Survey of Advanced Technology in the Canadian Food Processing Industry*. This was one of the first surveys of the Canadian food processing industry specifically on their innovation activities. The survey covered questions about advanced technology use, general firm and establishment characteristics, as well as questions about the benefits and obstacles of innovation adoption (Baldwin, Sabourin and Smith 2003). This survey did not link innovative activity with firm characteristics and market access. With the literature on the importance of knowledge spillovers and market access to innovative activity, this deficiency in the data did not allow for these factors to be analyzed, therefore the Canadian Agricultural Innovation Research Network (CAIRN) developed its own survey of innovation in food processing.

5.1.1 Survey Construction

A lack of primary data on innovation activities and spatial characteristics of food processors in Western Canada, necessitated a survey on innovation. The survey was designed to link innovation activity with the location of food processors, market access, firm attributes (size, revenue, ownership structure, age of firm) and industry characteristics. The survey was constructed in a manner to collect this data in the most efficient way possible.

The survey design was based on previous innovation literature and on a number of different surveys on innovation in Canada and around the world. These included the work by Statistics Canada of the *Biotechnology Use and Development Survey – 2003*, S*urvey of Innovation 2003* and the *Survey of Advanced Technology in the Canadian Food Processing Industry* conducted in 1998. The literature used in the development of the survey included work by the Organization for Economic Co-operation and Development (OECD), *The Measurement of Scientific and Technological Activities; Proposed Guidelines for Collecting and Interpreting Technological Innovation Data* and a working paper by Salay, Caswell and Roberts at the University of Massachusetts, titled *Survey Instrument for Case Studies of Food Safety in Innovation*.

The survey gathered additional information that is not part of this thesis, but that will be beneficial to future researchers of innovation in food processing in Western Canada. The questionnaire was very detailed and required a significant time contribution by respondents. A copy of the questionnaire is contained in Appendix A. The survey contained 25 questions with some questions having multiple parts to them. The questionnaire can be divided into seven main sections.

The first section of the questionnaire encompassed questions one through six. These questions focused on basic firm characteristics such as the age and ownership structure of the firm and the products they produce. In this section, firms also identified the region in which they were located by including the first three digits of their postal code, known as the Forward Sortation Area (FSA). By identifying the FSA of the firm, geographic information systems (GIS) could be used to include spatial variables in the analysis. This determines how the location of the firm affects its innovation activities.

The second section of the questionnaire focused on the markets in which firms purchased their inputs and sold their goods. This section included questions seven through nine. Product markets were divided into local, regional, national and international markets. With regards to international markets, firms were asked to list the countries they exported to, or to identify reasons why they did not export.

The third section of the questionnaire contained questions specifically regarding innovation. Definitions for innovation, including self declared participation in product and process innovation, were included for firms at the beginning of this section. Question ten asked firms to self identify if they introduced innovations that were new to their market or new to their firm. The responses from this question were used as the dependent variables in the regression analysis that follow this chapter.

This third section of the questionnaire also contained questions eleven through seventeen. These questions asked firms about their expenditure on innovation activities, the source of their innovation and the impact innovation had on their firm. In addition, this section contained a question about factors that hampered innovation activities within the firm.

Question 18, in the fourth section of the questionnaire, focused on the competitiveness of the firms. Firms were asked to rate, on a scale of one to five, with one being not damaging and five being very damaging, how a variety of factors hampered their competitiveness within the food processing industry. This question played a crucial role in the analysis of competitive conditions within the food processing industry.

The other two questions from the survey that were relevant to this thesis were the number of full time equivalent staff and the revenue of the business in 2002, 2003 and 2004. Firms were asked to fill in the number of full time equivalent staff employed by their business in each of the respective years between 2002 and 2004. The number of employees was not grouped into categories in the questionnaire.

Firms were then asked to identify which revenue bracket they fell into in each of the respective years between 2002 and 2004. Revenue brackets were used in the understanding that firms may be more willing to share revenue information if exact revenue was not asked for. The revenue brackets were divided into six different groups with the lowest bracket having revenue under $250,000 and the highest bracket having revenue over $10 million.

The remaining sections of the questionnaire that were not used in this thesis included a section on government sponsored programs, the activity of research and development units with the firm, and the education level and background of research and development managers of the food processing firm. These questions were included in the survey to provide in depth analysis of firm activity, but were not deemed necessary to test the hypothesis of this thesis

To assess the content of the questionnaire, the survey was reviewed by an outside marketing professor in the College of Commerce at the University of Saskatchewan. The survey was then sent for three pilot tests. At the completion of the test surveys, minor changes were made to improve the clarity of the survey.

After consultation with the Manitoba and Saskatchewan provincial food processing associations the survey was developed into an on-line survey that was delivered to food processors via e-mail. Industry contacts noted that almost all food processors had e-mail accounts, and that the few food processors that did not, were likely “hobby firms” and therefore not relevant to this study. After consulting the food processing associations, the decision to provide food processors with an on-line survey was made to simplify delivery of the survey to firms, potentially increase the response rate of the survey and for ease of data collection.

The on-line survey divided the questionnaire into five pages. Food processing firms were sent an e-mail introducing the survey and its motivation, with a link to the Internet location of the survey. Firms were asked to click on the link and participate in the survey. The opening page of the survey was the consent form. If respondents agreed to the conditions of the consent form, they were required to provide an e-mail address in order to proceed into the question section of the survey. An e-mail address was required to reduce the possibility that the same person would answer the survey numerous times. Respondents then proceeded through the survey and answered questions either by using a drop down box, or typing words or numbers in the required fields. At the end of each of the five sections, the responses of firms were saved before allowing advancement to the next section.

The data supplied by the firms was saved directly into a database maintained by the Canada Rural Economy Research Lab (C-RERL). To ensure confidentiality, each respondent was assigned an identification number after completing the survey. The database made public by C-RERL, includes only the assigned identification number, not the e-mail address of the firm.

5.1.2 Sample Description

Initially, the provincial food processing associations in British Columbia, Alberta, Saskatchewan and Manitoba were approached to ask for their cooperation in the distribution of the survey to their members. After meeting with the associations, three out of the four provincial associations agreed to supply membership lists and an introductory e-mail to their members in support of the survey.

The food processing association in British Columbia is a quasi-governmental organization. It is in a re-building phase and run by government employees. This association had a complete governmental listing of food processors in the province. The association said they had contact information for approximately 1,200 food processors. Of those 1,200, there were 788 firms with active e-mail accounts. These 788 firms were sent an e-mail by the Communications Officer for the British Columbia Food Processors Association asking them to complete the survey at the link included in the e-mail. Follow up telephone calls asking for firm's participation and four follow up e-mails were sent over a period of ten weeks to encourage participation in the survey.

Approximately 15 percent of e-mail accounts were inactive or incorrect addresses. Therefore, there were 668 food processors in British Columbia that received the e-mail requesting participation in the survey. From these 668, 19 firms partially completed the survey and 49 firms fully completed the survey. This was an overall response rate of 10 percent.

The distribution of surveys to food processors in Saskatchewan and Manitoba was very similar to that of British Columbia. The Saskatchewan Food Processors Association and Manitoba Food Processors Association both cooperated in the distribution of the survey to its members. In addition, the provincial government listings of food processors located in their respective provinces was obtained to augment the list of the food processing associations. Again approximately 15 percent of e-mail accounts in Saskatchewan and Manitoba were inactive or incorrect addresses.

Taking this into account, the survey was distributed to 106 food processing firms in Saskatchewan and 170 firms in Manitoba. After follow up phone calls and e-mails to all food processing firms that the survey was distributed to, Saskatchewan had a response rate of 18 percent and had 17 fully completed surveys. Manitoba had a response rate of 12 percent and had 14 fully completed surveys.

The Alberta Food Processors Association did not cooperate with the distribution of this survey to its members. A list of active food processors is maintained by the Alberta provincial government. Using this list to compile a directory of e-mail addresses, the survey was distributed directly to food processors from the University of Saskatchewan. There were 275 food processors in Alberta contacted and asked to participate in the survey. After follow up phone calls and numerous follow up e-mails, there were 26 fully completed surveys by Alberta processors, accounting for a response rate of 11 percent.

Overall, the survey was distributed to 1,219 food processors across Western Canada. There was a 13 percent response rate from these firms, which was consistent with the response rate of 12 percent - 15 percent that industry contacts had suggested. While the response rate was not as high as desired, 106 surveys were fully completed by food processors, allowing for analysis on innovation activities of food processing firms in Western Canada.

5.2 Innovation Data

The survey gathered information on the innovation activity of food processing firms, firm characteristics and location. Firms were asked to self identify if they introduced innovation into their business of their market during the years 2002 through 2004. The primary purpose of the survey was to link location with firm characteristics and innovative activity. Therefore, this survey did not measure the level of innovative activity; it only asked if firms were innovating.

Each of the six factors, described in the theoretical framework, that influence the innovation activities of food processing firms are represented by a number of variables that are used in the analysis of the data. While theory directs the factors that should be included in the empirical analysis, it does not explicitly demonstrate how these factors should be measured or which variables (or proxies) should be included in an analysis of innovative activities. Therefore, a number of variables are included in each vector to determine the effect each factor has on innovative activity.

In some of these factors, the variables are divided into exogenous and endogenous variables. The endogenous variables are related to the innovation activities of firms, yet it is difficult to determine the causality of the relationship. It is unknown whether the probability of innovation activity increases because of the variable, or if the variable existed because of the innovation activity. Because of the unidentified relationship, these variables are included in the analysis to avoid omitting variables that may be relevant to the innovation activities of food processing firms.

One method of dealing with the potential endogeneity issues of the variables is to use instrumental variables. This empirical method uses an exogenous variable (instrumental variable), that is highly correlated with the original variables, but this instrumental variable is not correlated with the original variable (Gujarati 2003). This method has proven to be an effective empirical method to deal with endogenous variables, but for this thesis and many other empirical research projects, there were no suitable variables to use as instruments for the analysis. That is, almost all of the variables that would be suitable instruments are also related to innovation.

Correlation analysis was performed on the binary innovation variable and the variables that had potential endogeneity problems. The variables with a high degree of correlation to innovation were omitted from the step wise analysis. This ensured that endogenous variables were excluded from the analysis, and limited the potential that necessary variables accidentally omitted from the final model. The tables below list the exogenous variables, and the variables that potentially suffer from an endogenous relationship with innovation.

5.2.1 Market Access Data

The questionnaire included several questions about market access. There were specific questions regarding where firms bought and sold products, and which countries they exported to. Also, firms were required to provide the first three digits of their postal code. This allowed for the calculation of a number of spatial variables including the distance to an urban center with population over 100,000, and the population within an 800 km radius of the firm. Table 5.1 shows the variables used for market access data, the variable name and data source.

Table 5.1: Market Access Variables

Variable Description	Variable Name	Data Source	Survey Question Number
Exogenous Variables			
Population within 100 kms of firm	pop_100	C-RERL	
Population between 100 and 200 kms of firm	pop_100_200	C-RERL	
Population between 200 and 300 kms of firm	pop_200_300	C-RERL	
Population between 300 and 400 kms of firm	pop_300_400	C-RERL	
Population between 400 and 500 kms of firm	pop_400_500	C-RERL	
Population between 500 and 600 kms of firm	pop_500_600	C-RERL	
Population between 600 and 700 kms of firm	pop_600_700	C-RERL	
Population between 700 and 800 kms of firm	pop_700_800	C-RERL	
Distance from firm to every city with population over 100,000 in Western Canada and Thunder Bay	dist_*city abbreviation*	C-RERL	
Distance to Minneapolis/St. Paul	dist_minn	C-RERL	
Distance to Denver	dist_denver	C-RERL	
Distance to Seattle	dist_seattle	C-RERL	
Business sold goods or services locally (within 100kms)	sell_local	Innovation Survey	7a
Business sold goods or services regionally (within province)	sell_reg	Innovation Survey	7b
Business sold goods or services nationally (outside province)	sell-nat	Innovation Survey	7c
Business sold goods or services to the United States	sell_us	Innovation Survey	7d
Business sold goods or services to countries other than the United States	sell_oth	Innovation Survey	7e

Because of the geo-coded innovation survey, this thesis is able to link location and market access with innovation. This is an important aspect to the analysis of this thesis.

5.2.2 Labour Data

The labour data gathered from the innovation survey has variables that potentially suffer from endogeneity. Theory substantiates the importance of skilled labour to innovation activities; therefore these variables are included in the regression analysis. Questions arise as to whether access to skilled labour increases the probability that firms will participate in innovation activities, or the implementation of innovation in a food processing firm necessitates the hiring of skilled labour to manage and operate the innovation. Table 5.2 shows the variable description, variable name and the source of the data.

Table 5.2: Labour Variables

Variable Description	Variable Name	Data Source	Survey Question #
Potentially Endogenous Variables			
Importance of research and development staff to business's innovation activities	imp_rd_staff	Innovation Survey	13a
Degree of damage lack of trained local (within 100 kms) labour force had on innovation activities or projects	dmg_lk_lbr_loc	Innovation Survey	17c
Degree of damage on business's innovation activities or projects from lack of qualified labour force available anywhere	dmg_lk_lbr_out	Innovation Survey	17d
Degree to which lack of trained local (within 100 kms) labour force had on hampering business's competitiveness within industry	cmp_lk_lbr_loc	Innovation Survey	18c
Degree to which lack of qualified labour force available anywhere had on hampering business's competitiveness within industry	cmp_lk_lbr_out	Innovation Survey	18d

Access to skilled labour is an important aspect of firm productivity. Access to skilled labour should therefore increase the probability that a food processing firm will participate in innovative activity.

5.2.3 Network Data

The questionnaire included several questions about the network of the firm. The network of a firm includes the clients, competitors, suppliers and other contacts of a business. Much of the data gathered to analyze the impact of a firm's network on its innovation activities potentially suffers endogeneity problems. Table 5.3 gives the variable description, variable name and source of the data for the network variables.

Table 5.3: Network Variables

Variable Description	Variable Name	Source	Survey Question #
Exogenous Variables			
Firm provides contract services to other firms or organizations	cont_to	Innovation Survey	4
Firm uses contract services of other firms or organizations	cont_out	Innovation Survey	5
Potentially Endogenous Variables			
Importance of local suppliers (within 100kms) of equipment, materials, components or software to business's innovation activities	imp_supp_loc	Innovation Survey	13c
Importance of suppliers (outside 100kms) of equipment, materials, components or software to business's innovation activities	imp_supp_out	Innovation Survey	13d
Importance of clients or customers to business's innovation activities	imp_cli_cust	Innovation Survey	13e
Importance of competitors or other enterprises within local area (within 100 kms) to business's innovation activities	imp_comp_loc	Innovation Survey	13f
Importance of competitors or other enterprises outside local area (outside 100kms) to business's innovation activities	imp_comp_out	Innovation Survey	13g
Importance of consultants, commercial labs or private R&D institutes to business's innovation activities	imp_cons_priv	Innovation Survey	13h
Importance of universities or other higher education institutions to business's innovation activities	imp_un	Innovation Survey	13i
Importance of government or public research institutes to business's innovation activities	imp_govt_pub	Innovation Survey	13j
Importance of conferences, trade fairs, exhibitions to business's innovation activities	imp_conf_exh	Innovation Survey	13k
Importance of scientific journals and trade/technical publications to business's innovation activities	imp_jnl_pubs	Innovation Survey	13l
Importance of professional and industry associations to business's innovation activities	imp_assoc	Innovation Survey	13m
Degree of damage lack of information on potential partners had on business's innovation activities	dmg_lk_info_prtn	Innovation Survey	17g
Degree of damage on business's innovation activities from difficulty in finding cooperation partners for innovation	dmg_lk_tech	Innovation Survey	17h

Previous literature on the adoption of innovation proves the importance of a firm's network to its innovation activities. The food processing industry relies on knowledge spillovers of innovation within the industry, and from firms outside the industry. There has not been a definitive way proposed to measure the impact of a firm's network on its innovation activities, therefore all the above variables are included.

5.2.4 Regional Characteristics Data

The data for regional characteristics are from the innovation survey and from C-RERL. With firms identifying the first three digits of their postal code, C-RERL determined which province the firm was located in, and created dummy variables based on this information. The provincial dummy's allowed for the inclusion of characteristics specific to the province where the firm was located. The dummy variables capture common provincial effects such as tax rates, government policy and business environment. This variable will verify if regional advantages exist for innovative activity of food processors located in specific provinces. Table 5.4 gives the variable description, the variable name and the source of the data.

Table 5.4: Regional Characteristics Variables

Variable Description	Variable Name	Source	Survey Question #
Exogenous Variables			
Regional identification for British Columbia	bc_dm	C-RERL	
Regional identification for Alberta	ab_dm	C-RERL	
Regional identification for Saskatchewan	sk_dm	C-RERL	
Regional identification for Manitoba	mb_dm	C-RERL	
Potentially Endogenous Variables			
Degree of damage to business's innovation activities due to location of business	dmg_loc_bus	Innovation Survey	17n
Degree of damage to business's innovation activities due to lack of access to airports or rail service for business	dmg_lk_apt	Innovation Survey	17p
Degree of damage to business's innovation activities due to lack of access to adequate road system	dmg_lk_rd	Innovation Survey	17q

The other variables included for the data on regional characteristics may suffer from endogeneity, yet account for the infrastructure of the area where a firm is located. Infrastructure such as access to roads, railroads and airports could influence innovative activity. If firms do not have transportation to get their products to market or for acquiring inputs, they will be unlikely to participate in innovation activities.

5.2.5 Firm Attributes Data

The data on firm attributes was obtained from the innovation survey. The exogenous data on firm attributes includes the year the business was established, the ownership structure of the firm and the size of the firm. Table 5.5 shows the variable description, the variable name and the source of the data.

Table 5.5: Firm Attribute Variables

Variable Description	Variable Name	Source	Survey Question #
Exogenous Variables			
Year of establishment	year	Innovation Survey	2
Privately owned business	priv	Innovation Survey	3a
Affiliation with a multinational enterprise	mne	Innovation Survey	3b
Number of employees 2002	emp_02	Innovation Survey	21a
Number of employees 2003	emp_03	Innovation Survey	21b
Number of employees 2004	emp_04	Innovation Survey	21c
Revenue of firm 2002	rev_02	Innovation Survey	25a
Revenue of firm 2003	rev_03	Innovation Survey	25b
Revenue of firm 2004	rev_04	Innovation Survey	25c
Potentially Endogenous Variables			
Undertook in-house R&D	dm_exp_int_rd	Innovation Survey	12a
Undertook extramural R&D	dm_exp_ext_rd	Innovation Survey	12b
Acquired machinery, equipment and software to produce new or improved products	dm_exp_mchn	Innovation Survey	12c
Acquired other external knowledge to develop new or improved products	dm_exp_ext_knl	Innovation Survey	12d
Training for personnel for the development or introduction of new or improved products	dm_exp_trn	Innovation Survey	12e
Other preparations to implement innovation	dm_exp_oth_inn	Innovation Survey	12f
Degree of damage lack of funds within business had on innovation activities or projects	dmg_lk_fnd	Innovation Survey	17a
Degree of damage lack of financing options from sources outside business had on innovation activities or projects	dmg_lk_fin	Innovation Survey	17b
Importance of other business units within business to business's innovation activities	imp_oth_bus	Innovation Survey	13b

The variables with potential endogeneity are important as they represent firm characteristics that may be essential to the adoption of innovation by firms. The contribution these firm attributes make to innovation activities are difficult to measure, and result in potential endogeneity in the model.

5.2.6 Competitive Conditions Data

The data on competitive conditions was all obtained from the innovation survey. The competitive conditions a firm faces will influence its innovation activities. These factors are difficult to develop a measure for. The measures used in the survey, potentially suffer from endogeneity in the empirical model, but are included because they represent and important aspect of the innovation decisions of firms. Table 5.6 gives the variable description, variable name and source of the data for the competitive conditions variables.

Table 5.6: Competitive Conditions Variables

Variable Description	Variable Name	Source	Survey Question #
Potentially Endogenous Variables			
Impact increased range of goods or services had on business	ip_rng_gs	Innovation Survey	16a
Impact from entering new domestic market or increased market share had on business	ip_dm_mkt	Innovation Survey	16b
Impact improved quality of goods or services had on business	ip_qlt_gs	Innovation Survey	16c
Impact from entering new international markets or increased market share had on business	ip_intl_mkt	Innovation Survey	16d
Impact new or significantly improved products had on business keeping up with competitors	ip_bus_comp	Innovation Survey	16e
Impact increased capacity of production or service provision had on business	ip_inc_cap	Innovation Survey	16f
Impact reduced labour costs (per unit output) from improved processes had on business	ip_rd_lbr_cst	Innovation Survey	16g
Impact reduced materials and energy (per unit output) from improved processes had on business	ip_rd_mat	Innovation Survey	16h
Impact improved inventory management from improved processes had on business	ip_inv_mgt	Innovation Survey	16i
Impact on business from meeting regulatory requirements through new goods/services or processes	ip_reg_rqt	Innovation Survey	16j
Degree of damage to business's innovation activities because there was no need to innovate due to prior innovations	dmg_pr_inn	Innovation Survey	17r
Degree of damage to business's innovation activities because there was no demand for innovations	dmg_no_dmd	Innovation Survey	17s

The competitive conditions a firm faces, also represents the industry structure of the food processing firm. If firm's were a monopoly in their market, the may have greater incentive to innovate as they can capture all the rents available from the innovation. In contrast, some theory hypothesizes that firms operating under competitive condition have a greater probability of implementing innovation as they must continually strive to improve productivity to remain competitive in the market.

5.3 Factors Influencing Innovative Activity in Food Processing

There is little empirical work on how to measure the factors that influence the innovation decisions and activities of food processing firms. Previous theoretical work identifies the groups of variables to be included in the empirical analysis, but does not substantiate how these variables should be measured or how much each of these groups of variables contribute to innovative activity. To provide some understanding of how these variables affect innovative activity in the food processing industry, exploratory empirical procedures were used. All empirical analysis was done using the statistical software Stata 9.

Initially principle component analysis was used to identify which group of variables had the greatest influence on the innovative activity of firms. Following the principle component analysis, empirical work was conducted to determine which specific variables were to be included in the final model. To do this, step wise backward regression modeling was used. After the final model had been specified, a probit regression model was used to determine which variables influenced innovative activity in food processing firms in Western Canada.

The probit model regressions are:

$$INNOV = \beta_0 + \beta_1 MKT + \beta_2 LBR + \beta_3 NET + \beta_4 REG + \beta_5 FRM + \beta_6 COMP + e \tag{5.1}$$

$$INNMKT = \beta_0 + \beta_1 MKT + \beta_2 LBR + \beta_3 NET + \beta_4 REG + \beta_5 FRM + \beta_6 COMP + e \tag{5.1a}$$

$$INNBUS = \beta_0 + \beta_1 MKT + \beta_2 LBR + \beta_3 NET + \beta_4 REG + \beta_5 FRM + \beta_6 COMP + e \tag{5.1b}$$

where (*INNOV*) represents a binary variable for the firm's participation in innovation by introducing a product or process innovation into their business or market. The vector (*MKT*) contains variables to determine the influence of market access and (*LBR*) represents the variables accounting for the influence of labour markets. The vector (*NET*) is comprised of the variables capturing the network of the firm, while (*REG*) includes the regional characteristics influencing the firm. The last vector (*COMP*) consists of the variables measuring the competitive conditions of the firm. The dependent variable (*INNMKT*) in equation (5.1a) represents a binary variable for the firm's introduction of an innovative product or process into their market. Equation (5.1b) has the dependent variable (*INNBUS*) which represents a binary variable for the firm's introduction of product or process innovation into their business. The variables included in each factor for final model specification were determined by using step-wise analysis. The descriptions of the variables included in each factor are listed above in Section 5.2.

5.3.1 Principle Component Analysis

The initial method used to analyze the data was principle component analysis (PCA). PCA is often suggested as a way to deal with multicollinearity, a problem which is widespread in the variables listed above. PCA suggests that the blocks of variables can be summarized into a single scalar variable that captures the information contained by all the variables in the original data (Deller et. al 2001). This means that the variables presented in the previous tables are condensed and represent the six components: market access, labour characteristics, regional characteristics, network characteristics, firm attributes, and competitiveness factors in a regression model. Ideally, this method captures the essence of the original variables, but reduces the groups of variables into a single measure representing each factor based on their largest eigen vector.

The scalar measures that represent the set of related variables are linear combinations of the original variables where the linear weights are the eigenvectors of the correlation matrix between the set of related variables (Deller et. al 2001). Each factor is constructed orthogonal or uncorrelated to the others (Maddala 1992). PCA is a method of inspecting the data for directions of variability and using this information to reduce the collection of variables by summarizing each block into a single measure (Deller et. al 2001).

The procedure of principle component analysis suffers from some problems. While the first principal component reported in the statistical program output, has the highest variance, it is not necessarily the one that is most highly correlated with the dependent variable. Also, with PCA, it is not known which individual variable(s) contributed the most to each factor. While PCA has its limitation, this approach was one of the few ways to deal with the large quantity of variables in this analysis.

5.3.2 Step Wise Regression Analysis

Principle component analysis does not provide insight into which individual variables are the most important to innovative activity in food processing firms. Step wise regression analysis was selected to provide insight into which variables were the most important. This method was chosen because of the sheer number of variables involved in the analysis.

Step wise backward regression analysis includes all the possible explanatory variables of the model, and then rejects them one at a time (Gujarati 2003). This general to specific model building is preferred because it reduces the likelihood that variables will be omitted from the model (Greene 2003). Caution must be exercised that the variables incorporated in the general model have a theoretical basis for being included in the large model. For this thesis, step wise backward regression was performed on each of the six factors individually to determine the most relevant variables for that factor. There is some risk with this method that the model may be mis-specified, but with the lack of previous work in this area to provide guidance, few other alternatives exist to analyze the number of variables that are potentially important to innovation activities in food processing firms.

Factor by factor, each set of variables had step wise backward regression performed on it. Variables with a high degree of correlation were included in the larger model, while variables with the least correlation were dropped, and the model re-estimated. The significance level of the analysis was set at 15 percent to ensure that each potentially significant variable was not improperly omitted in the final model. The variables for each factor that met this criterion were included for analysis in the final model specification.

While this process suffers from problems of multicollinearity and possible mis-specification of the model, there are few alternative ways to specify a model with scores of variables due to the lack of previous work in this area. This analysis will provide some insight into which variables increase the probability that food processing firms will participate in innovative activity, and will add to the literature.

5.3.4 Dependent Variables

The dependent variables for equations (5.1), (5.1a) and (5.1b) all originate from the innovation survey. Question 10 of the questionnaire asked firms to self identify if they introduced innovation that were new to their market or new to their business. For the dependent variable (*INNOV*) firms were denoted with a one if they identified that they introduced innovation, regardless if the innovation was new to their business or their market. This differed from the identification of the other dependent variables.

The dependent variable (*INNMKT*) was constructed with firms being identified with a one, if they indicated that they introduced innovation new to their market, and were identified with a zero for all other firms in the survey. The dependent variable (*INNBUS*) identified firms that had introduced product or process innovation to their business with a one. All other firms in the survey were identified with a zero. The specification of three dependent variables allowed for further analysis into the innovation activities of food processing firms.

5.3.5 Probit Regression

After the step-wise regression analysis, specific variables from each factor were identified as being important in the final model specification. To analyze this model, a probit regression was used. While the logit model was another alternative to use for this analysis, for all practical purposes the probit and logit models yield similar results. The probit model was chosen for this analysis as the cumulative distribution of the residuals is assumed to be normal.

5.4 Chapter Summary

The procedures used to ascertain the firm characteristics that influenced innovative activity in food processing firms were identified in this chapter. A description of the innovation survey and the collection of data was given. For each factor identified in the theoretical framework, the variables used to measure these factors were listed and described. After some initial exploratory work with principle component analysis, step wise regression analysis and its facilitation in the construction of the final model specification are described. A description of the probit regression used for analysis on the final model specification concludes the chapter. The results of the exploratory work and the hypothesis tests are included in the next chapter.

Chapter 6: Hypotheses Test Results

6.0 Introduction

This chapter presents the results of the estimated econometric models and describes the results of the hypotheses tests. The chapter begins with a presentation of how the explanatory variables were selected and how the benchmark model was determined. The chapter then follows with the results of the initial empirical method used to analyze the data, principle component analysis. This is followed with the presentation of the step wise regression results, and the final specification of the benchmark model. The results are presented with the ultimate goal of addressing the hypotheses of this thesis, which concludes the chapter. Due to the numerous regressions required for investigation of the data, only selected results are presented and analyzed.

6.1 Determination of the Best Model

Previous literature exists on the factors that contribute to innovation activities of firms, but little consensus exists on how to measure these factors. Therefore, the dataset used in this analysis had a large number of explanatory variables. It was important to test the effects of inserting different variables into the model to determine which variables provided the optimal results, and to understand how these changes affected the model. This section examines the different methods used to find an optimal set of explanatory variables for this analysis. This optimal set of variables will be referred to as the "benchmark model". Numerous series of regressions were estimated to establish this benchmark model, but most will not be shown in this chapter.

6.1.1 Determination of Significant Coefficients

The statistical test used to determine the validity of the estimated coefficients is the standard t-test. The t-test is used to assess whether individual coefficients are significant in the model. This test is one of the most common methods to determine if the estimated coefficients are statistically significant. For the purposes of this research the null hypothesis H_0 was that the estimate equals zero, while the alternative hypothesis H_1 was that the absolute value of the estimate is not equal to zero. The two tailed t-test is used for all coefficients in an effort to avoid a Type I error.

6.1.2 Adding Variables

In order to asses the effects that different individual and groups of variables had on the overall model, several models were estimated. Individual variables and groups of variables were added to the specified group of core variables incrementally to determine the benchmark model. When the benchmark model was identified, individual variables and groups of variables were once again added incrementally to ascertain the effects these changes had on the benchmark model. In general it was found that as individual variables or groups of variables were added to the model, coefficient signs generally did not change, but a significant decline in t-statistics occurred. This behaviour could indicate collinearity between the variables or the variable groups. It could also indicate that the benchmark model was superior in explaining the dependent variables.

6.2 Sample Descriptive Statistics

Table 6.1 provides descriptions for several of the explanatory variables included in the analysis. The descriptive statistics are provided to offer a general overview of the sample that is used for this analysis. These statistics provide evidence that a representative sample of food processors in Western Canada was used for this study. A further listing of descriptive statistics is located in Appendix B.

Almost 83 percent of firms that answered the questionnaire self identified that they introduced innovation into their business, into their market, or into both their business and market. Dividing these two areas, 45 firms indicated that they introduced innovation into their market, while 82 identified that they introduced innovation into their business.

Of the 106 firms that answered the survey, 91 were privately owned, while 11 of the remaining firms were an affiliate or partner of a multi-national enterprise. The sampled firms had an average of 36.59 employees in 2004, while the average year of establishment for the sampled firms was 1986. The survey sample was distributed across Western Canada. There were 49 firms that completed the survey from British Columbia, 26 firms from Alberta, 17 from Saskatchewan and 14 from Manitoba.

The firms that completed the survey were a representative sample of food processing firms in Western Canada. While the empirical results of this thesis would have been improved with a greater number of completed surveys, the received responses represented a diverse mix of companies within the industry. This is demonstrated by the distribution of firms by revenue category, and by the standard deviation for number of employees.

Table 6.1 – Selected Sample Descriptive Statistics

Variable Name	Number of Firms			
Introduced innovation to business or market	89			
Introduced innovation to market	45			
Introduced innovation to business	82			
Privately owned business	91			
Business is an affiliate or partner of a Multi-National Enterprise	11			
Revenue of business 2004	*$0 - $250000*	*$250 000 -$1m*	*over $10 m*	
(top 3 revenue categories)	31	19	15	
Location of business	*MB*	*SK*	*AB*	*BC*
	14	17	26	49

	Mean	Standard Deviation	Minimum Value	Maximum Value
Year business was established	1986	19.07	1885	2004
Number of Employees 2004	36.59	94.08	0	800

Source: Innovation Survey, Author's Calculations

6.3 Principle Component Analysis

The primary approach to testing the hypotheses of this thesis was to use principle component analysis (PCA). This method has been used successfully in other research where a large number of variables describe a particular attribute, as is the case in this thesis (Deller et. al 2001). With PCA the variables describing each attribute are condensed into a single scalar measure that captures the information contained in the original variables. These measures can then be used to analyze the research question.

Using the statistical software Stata 9, PCA was conducted on each of the six attributes. The highest eigenvector from the analysis was used to calculate the single scalar measure for that attribute. The original variables were multiplied by the corresponding eigenvector, than these best figures were summed horizontally to give the scalar variable. This new variable is assumed to summarize the information of the original variables.

Early on, the calculation of the eigenvectors for each attribute seemed promising, even though the cumulative variance explained by the scalar measure for two of the factors was somewhat low. The lowest cumulative variance explained was 39.57 percent for the regional attributes and 39.89 percent for the network variables. The highest cumulative variance explained was 64.63 percent for the labour variables. Further results of the eigenvectors for each attribute are provided in Appendix C.

The single scalar variable for each attribute was then included in a probit regression using three different dependent variables. The dependent variables were binary variables with the main model using the variable *INNOV* which accounted for the firm introducing innovation into the market, their business or both. The other dependent variables were *INNMKT*, which accounted for the introduction of innovation into the market, and *INNBUS* accounting for innovation introduced into the business.

The results of the PCA regression analysis were dismal. The scalar variable for competitive conditions was excluded from the regression analysis due to the risk of endogeneity associated with these variables and the dependent variables. The highest t-statistic for any of the scalar variables included in the analysis was 1.56, with the majority of the scalar variables having t-statistics well below 1.00.

With these results, further analysis was considered necessary. In addition to the scalar variables, several variables were identified from previous literature, as important to innovation activities. These variables were included individually and then in groups to try and improve the results for the PCA. The addition and removal of these variables did not improve the regressions results.

The next step was to evaluate different dependent variables. Because of the potential endogeneity between innovation and the competitive conditions variables, each variable in this group was used as a dependent variable in a regression with the scalar variables. These regressions also did not yield significant results.

Correlation analysis was then conducted on the original variables in each of the six factors. Within the group, variables with a correlation greater than .60 were eliminated from the analysis of that specific attribute. Correlation analysis was then completed on the remaining variables and the dependent variables that accounted for the introduction of innovation into the market, the business or both. Again, any variables with correlation greater than .60 were excluded from the PCA. The above steps were repeated on the selected variables with similar results. The probit regressions on these chosen variables also did not yield significant results.

Generally, it appeared that the PCA approach was discarding the relevant explanatory variables that were influencing innovation activities of food processors. While principle component analysis was to be a key empirical method used to analyze the data, the non-significance of the results necessitated the application of another method. While step wise analysis was not initially the preferred empirical method, few alternatives existed after the insignificant results of the principle component analysis.

6.4 Step Wise Regression Analysis

Step wise regression analysis was used to provide insight into which individual variables contribute to the innovation activities of food processing firms. To test which individual variables are most important, step wise regression analysis was performed on each group of variables, using three different dependent variables, to identify the significant variables in each vector. Therefore each group of variables had three stepwise regressions to identify the "important" variables for that group.

The binary variable *INNOV* is 1 if the firm introduced innovation into its business, market or both, or 0 if it did not introduce innovation. The introduction of innovation by a firm into its market is represented by a 1 in the dependent variable *INNMKT*, and a 0 otherwise. The last dependent variable *INNBUS*, takes the value of 1 if the firm introduced innovation into its business, and 0 if there was no introduction of innovation to the business. The level of significance for all the step wise regressions was 15 percent, to ensure that potentially relevant variables were not omitted in this part of the analysis.

Explanatory variables included in the tables below were found to be significant in the step wise regression. In the larger groups of variables, such as market access, the criterion set for inclusion in the final step wise regression, was that each variable must be found to be significant in two or more of the regressions. In some cases, specific groups of variables within the larger group were found to be significant. These groups may have only had one variable significant in each of the three regressions performed, but this group had obvious relevance to innovative activities, therefore was included in the final step wise model.

In the smaller groups of variables, a variable that was found to be significant in any of the three regressions was included in the final model. Columns with an *n/a* indicate that the variable was not significant in the step wise regression or was removed by the statistical program because of the restrictions placed on the model (probability =.15).

6.4.1 Market Access Variables

The market access variables that were the most significant in the step wise regression can be divided into three main areas. First, the population within a 500 km radius of the firm was found to be significant. These variables represent the market size available to a firm. The other population variables (population between 500 and 800 km) were found to be insignificant in the step wise results. Market access is important to the firm as it determines the current and potential market available to a firm, and provides firms with amenities such as improved business services and access to a larger labour pool.

The market (local, regional, export) where firm's sold their goods and services was also significant. This group of variables had one variable significant in each of the three regressions, but no particular variable was significant in each model. This indicates that the final product market may influence innovation activities, but at this stage, it is unclear which variable has the greatest influence on innovation activities, therefore these three variables are included in the final step wise regressions. This group of variables determines the effects competitive markets have on the innovation activities of firms.

Distance to urban centers was also significant in this group of step wise regressions. Across all three regressions, the cities of Abbotsford, Calgary and Saskatoon were significant in the step wise regression. This supports the idea that location is an important factor in the innovation decisions of firms. Table 6.2 shows the selected empirical results from the step wise regressions that were discussed above.

Table 6.2 – Selected Step Wise Regression Results: Market Access

Dependent Variable	**INNOV**	**INNMKT**	**INNBUS**
Independent Variable		**Coefficient (Standard Error)**	
Population within 100 to 200 km of firm	5.05e-06** (1.94e-06)	2.13e-06*** (6.04e-07)	3.40e-06*** (1.04e-06)
Population within 200 to 300 km of firm	-5.89e-06*** (1.93e-06)	n/a	-4.03e-06*** (1.39e-06)
Population within 300 to 400 km of firm	-5.69e-06*** (1.99e-06)	n/a	-2.74e-06** (1.25e-06)
Population within 400 to 500 km of firm	-2.75e-06** (1.11e-06)	1.11e-06*** (3.65e-07)	-3.09e-06** (1.13e-06)
Sell goods in regional market	-2.75e-06** (1.11e-06)	n/a	n/a
Sell goods in local market	n/a	n/a	-.0191*** (.0068)
Sell good in U.S. market	n/a	n/a	-.0187** (.0093)
Distance to Saskatoon (km)	-0.0291*** (.0102)	.0121*** (.0045)	-.0177*** (.0062)
Distance to Calgary (km)	.0507*** (.0184)	.0365*** (.0109)	.0412*** (.0143)
Distance to Abbotsford (km)	.1248** (.0523)	.1092** (.0458)	.1168** (.0451)

*, **, *** denote significance at 10 percent, 5 percent and 1 percent levels respectively.

6.4.2 Labour Market Variables

The step wise regression analysis on the labour market variables indicated that research and development staff were important to firm's innovation activities in all three step wise regressions. Also, the availability of qualified labour was significant in the model where the dependent variable accounted for the introduction of innovation into the market by the firm (*INNMKT*). These two variables were included in the final group for step wise regression analysis. Table 6.3 shows the empirical results for these variables.

Table 6.3 – Selected Step Wise Regression Results: Labour Market

Dependent Variable	**INNOV**	**INNMKT**	**INNBUS**
Independent Variable		**Coefficient (Standard Error)**	
Importance of research and development staff to business's innovation activities	.3301*** (.0996)	.1724*** (.0638)	.1826** (0.0731)
Degree to which lack of qualified labour force available anywhere had on hampering business's competitiveness within industry	n/a	-.2844** (.1407)	n/a

*, **, *** denote significance at 10 percent, 5 percent and 1 percent levels respectively.

6.4.3 Network Variables

Table 6.4 shows the empirical results for the network variables that were significant in the step wise analysis on this group of variables. Suppliers outside the local area and clients and customers of the business were shown to be significant and have a positive effect on innovation activities. Suppliers and competitors in the local area (within 100 km) were significant but had a negative sign with the coefficient, indicating that the local network of a firm may not be important to the innovation activities of firms. These variables were included in the final step wise model.

There is some question of casualty with these variables, with the fact that it is difficult to determine if the firm participated in innovation because of these factors, or if these factors were important to the firm after they had implemented innovation. Because of this unknown casualty of the relationship, these variables were included rather than omitting potentially relevant variables.

Table 6.4 – Selected Step Wise Regression Results: Network Variables

Dependent Variable	INNOV	INNMKT	INNBUS
Independent Variable		**Coefficient (Standard Error)**	
Importance of local competitors (within 100 km) to business's innovation activities	-.2462** (.1127)	n/a	-.2071** (.2433)
Importance of consultants or private institutes to business's innovation activities	.2267** (.1120)	n/a	n/a
Importance of suppliers (outside 100 km) to business's innovation activities	n/a	.1748** (.0768)	n/a
Importance of clients and customers to business's innovation activities	n/a	.1675** (.0809)	n/a
Importance of local suppliers (within 100 km) to business's innovation activities	n/a	-.1828** (.0827)	n/a

*, **, *** denote significance at 10 percent, 5 percent and 1 percent levels respectively.

6.4.4 Regional Variables

There were very few regional variables that were significant after the step wise regressions. The regional dummy variable for firms being located in the province of Alberta was the most consistent variable, with it being significant in two out of the three regressions. The regional dummy variable for firms located in Saskatchewan was also significant in the regression where the dependent variable was for firm's introducing innovation into the market (*INNMKT*). Regional variables accounting for access to infrastructure such as roads, airports and rail services, were not significant. Table 6.5 displays the selected step wise regressions results for the regional variables.

Table 6.5 – Selected Step Wise Regression Results: Regional Variables

Dependent Variable	INNOV	INNMKT	INNBUS
Independent Variable		**Coefficient (Standard Error)**	
ab_dm	-.7109** (.3169)	n/a	-.4914* (.3004)
sk_dm	n/a	.6776** (.3399)	n/a

*, **, *** denote significance at 10 percent, 5 percent and 1 percent levels respectively.

6.4.5 Firm Attribute Variables

Table 6.6 shows the selected significant variables for the step wise regressions on this group of variables. The year the firm was established was the variable most consistently significant in the three regressions. While the number of employees of the firm, and the revenue of the firm were not significant, a variable for the ownership structure of the firm appeared significant in the second regression. Also, the impact lack of financing had on the competitiveness of the business was significant in the second regression.

While this group of variables only had a small number of variables that were significant in the step wise regressions, previous literature indicates that firm attributes will play a large role in the innovation decisions of firms. Because of the strength of the previous literature, a variable for firm size (the number of full time equivalent employees) was included in the final step wise regression, even though it did not appear significant in the step wise regressions on this group of variables.

Table 6.6 – Selected Step Wise Regression Results: Firm Attribute Variables

Dependent Variable	**INNOV**	**INNMKT**	**INNBUS**
Independent Variable		**Coefficient (Standard Error)**	
Year of establishment	.0385*** (.0141)	n/a	.0279** (.0119)
Affiliated with a multinational enterprise	n/a	-.9992** (.4798)	n/a
Impact lack of financing had on competitiveness of business	n/a	-.17922** (.0801)	n/a

*, **, *** denote significance at 10 percent, 5 percent and 1 percent levels respectively.

6.4.6 Competitive Conditions Variables

The step wise regressions on the competitive conditions variables yielded three variables that were significant in two or more of the regressions. The significant variables were for the impact on the business from the introduction of new goods, the impact on the firm from meeting the regulatory requirements for the new goods, and the impact the increased range of goods or services had on the business.

Correlation analysis conducted between the dependent variables and these significant variables showed that very little correlation existed. The highest correlation between the dependent variables and these significant variables was .4860, but these variables still have a high degree of endogeneity with the dependent variables, therefore they are not included in the final step wise regressions. Table 6.7 displays the coefficients and standard errors of the significant variables from this group.

Table 6.7 – Selected Step Wise Regression Results: Competitive Conditions Variables

Dependent Variable	**INNOV**	**INNMKT**	**INNBUS**
Independent Variable		**Coefficient (Standard Error)**	
Impact new or significantly improved products had on keeping up with competitors	.4258* (.2359)	.2503** (.1018)	-.2291* (.1354)
Impact on business from meeting regulatory requirements of new goods/services	-.6216* (.3302)	-.1622* (.0904)	n/a
Impact increased range of goods or services had on business	n/a	.2873*** (.0992)	.3691*** (.1378)

*, **, *** denote significance at 10 percent, 5 percent and 1 percent levels respectively.

6.4.7 Step Wise Selected Variables

The selected variables identified in the sections and tables above were included in final step wise regressions models. Similar to the above analysis, three regressions were completed on the selected variables. The first regression had *INNOV* as the dependent variable. The other regressions had the dependent variables *INNMKT* and *INNBUS*. By completing step wise regressions on the variables described above, variables were identified to include in the final probit model. The variables included in this model are reported in Appendix B, and were the variables that were significant at the 10 percent, 5 percent or 1 percent level in at least one of the regressions. This step by step procedure, while not a regularly used empirical technique, proved to capture individual variables that are important to the innovation decisions of food processing firms in Western Canada.

6.5 Probit Model

From the final step wise regressions on the three dependent variables, a number of variables were pinpointed to include in the final benchmark model that identified factors that influence the innovation activities of food processors. In general, the significant variables from the final step wise regression, could be identified as belonging to a group of variables within the larger group (i.e., the market access group, had a collection of variables on population and a collection of variables on distances to major cities). The trends that existed within the different groups of variables, led to the inclusion of some additional explanatory variables that had previously been eliminated by the step wise procedure. These additional variables are reported in Appendix D.

The empirical procedure of step wise analysis identified some important groups of variables to include in the benchmark model. Initially, the regression models were analyzed including all observations. Very few results were statistically significant. This caused concern that problems existed in the data. Recognizing that the food processing industry in Western Canada may have a number of "hobby firms", the decision was made to exclude firms with three employees or less[1]. By including only firms with four employees or more, a number of explanatory variables became statistically significant. Thus specification of the benchmark models, and all results presented are based on the sampled firms with four or more employees.

The final specification of the benchmark model was done through the estimation of numerous models where individual variables and groups of variables were added to the core group of explanatory variables. This was repeated until a model was identified that had the greatest number of significant explanatory variable, and the highest factor explanation for innovative activity.

The final benchmark model has variables that are consistent with the literature, and had the greatest number of significant variables for the dependent variable *INNOV*. This dependent variable accounts for the firm's introduction of innovation into the market, their business or both, therefore this dependent variable was the main regression used to test the hypotheses. The results of this regression and the two other regressions with dependent variables INNMKT and INNBUS are presented in Table 6.8 at the end of this section.

The results of this regression suggest that market access and size play an integral part in the innovation activities of firms. Firms are more likely to innovate if they have a large population within a 200 km radius. This indicates that access to a larger market

[1] The food processing industry has a number of very small operations that are "hobbies" for the owners. The innovation process with these small firms is idiosyncratic and these very small firms were excluded from the analysis.

within a few hours drive of the firm, is important to the innovation activities of food processing firms. A one standard deviation change in the population within 200 km will increase the likelihood of food processing firms participating in innovative activities, by approximately 10 percent, which is a large magnitude.

A large market determines the current and potential market available to a firm. It also has many amenities to offer a firm. A large market offers a diverse labour pool, and specialized business services such as accountants, lawyers. Access to a large market offers the possibility of knowledge spillover from other industries located near the large market. Previous literature identified the importance of knowledge spillover to the food processing industry. Many factors may explain why market access is so important to the innovation activities of food processing firms

The proximity of the final product market for food processing firms also influences their innovation activities. Firms that sold their product into the local market (within 100 km) had a lower probability of participating in innovation activities. Firms may face less competition in their local market, therefore do not have the need to innovate to retain market share and competitiveness. Firms participating in broader markets (regionally, nationally or internationally) will participate in more innovation to be competitive in these larger markets. This supports the idea that firms participating in a more competitive market, must innovate to retain or expand their market share and remain competitive in the long run.

The proximity of firms to urban centers influences the innovation decisions of firms. Firms have a greater probability of participating in innovation if they are located away from the cities of Vancouver and Winnipeg. While this result may seem to conflict the previous results discussed about market access, a logical explanation may be that innovating firms are located in Alberta where there is access to a large market and they are at a distance from Vancouver and Winnipeg.

Firm attributes were also significant to innovation activities of food processing firms. The size of the firm, measured by the number of employees, was significant at the 5 percent level. This variable indicated that the larger the firm, the greater the probability that firms introduced innovation. A one standard deviation change in the size of the firm, increased the probability of firm's participating in innovation activities by 10 percent, a large extent by any measure.

In addition, newer firms were more likely to introduce innovation. This result supports the idea that new firms entering a competitive market must innovate to capture market share and experience long run growth. A one standard deviation change in the age of a firm will increase the probability of firms introducing innovations by 3 percent; not as large of magnitude as some of the other results, but still an important factor.

While similar results are significant in the other two regressions with dependent variables *INNMKT* and *INNBUS*, the results were not as highly significant as the main model with the dependent variable *INNOV*. This benchmark model explains 37 percent of the factors motivating firms to introduce innovation into the market, their business or both.

Table 6.8 – Probit Model: Step Wise Selected Variables

Dependent Variable	**INNOV**	**INNMKT**	**INNBUS**
Independent Variable		**Coefficient (Standard Error)**	
Sell products in local market	-.0151*	-.0037	-0.0095
	(.0078)	(.0058)	(.0062)
Sell products in U.S.	.0058	.0136*	.0088
	(.0123)	(.0078)	(.0109)
Business is privately owned	.6893	.2149	.6718
	(.6663)	(.4759)	(.5417)
# of employees in 2004	.0248**	.0025	.0104
	(.01119)	(.0018)	(.0071)
Population within 100 km of firm	1.31e-06*	3.43e-07	7.36e-07
	(7.20e-07)	(4.18e-07)	(5.44e-07)
Population within 100 to 200 km of firm	7.98e-07*	-7.72e-10	2.26e-07
	(4.68e-07)	(2.79e-07)	(3.66e-07)
Population within 200 to 300 km of firm	7.83e-07	-8.54e-08	8.94e-08
	(5.43e-07)	(2.78e-07)	(3.74e-07)
Population within 300 to 400 km of firm	8.52e-07*	3.55e-07	7.52e-07**
	(4.46e-07)	(2.89e-07)	(3.56e-07)
Distance to Winnipeg (km)	.0120**	.0008	.0092*
	(.0057)	(.0026)	(.0049)
Distance to Regina (km)	-.0055*	-.0018	-.0017
	(.0030)	(.0016)	(.0019)
Distance to Vancouver (km)	.0138**	.0004	.0105**
	(.0060)	(.0027)	(.0051)
Effect lack of labour available locally (within 100 km) had on competitiveness of firm	-.2889	-.0352	-.0729
	(.1757)	(.1183)	(.1350)
Year of establishment of business	.0368**	-.0045	.0228*
	(.0175)	(.0088)	(.0122)

*, **, *** denote significance at 10 percent, 5 percent and 1 percent levels respectively.

6.5.1 Additional Analysis of Probit Model

With the specification of a benchmark model, additional analysis was completed to evaluate the effects of changes to the model. Systematically, each of the six groups had explanatory variables from that collection, added into the specified benchmark model. As expected, the addition of variables for competitive conditions, regional characteristics, firm attributes and market access made no improvement on the model, and in the majority of cases made all the variables in the model highly insignificant.

Some interesting results did occur when the excluded labour variables from the stepwise analysis were included in the model. With the addition of the three labour variables (damage lack of labour available locally had on innovation activities, damage lack of labour available anywhere had on innovation activities, damage lack of labour available anywhere had on competitiveness) the significance of the previously identified variables in Table 6.8 remained the same, but the added labour variables were not significant. This suggests the innovation and the additional labour variables are not very correlated, but it is interesting to note that the addition of these variables, did not cause the t-statistics of the previously identified significant variables to fall below 1.00 as they did with the addition of the other factors.

More interesting results occurred with the addition of the excluded network variables from the step wise analysis. With the addition of these three variables (importance of local suppliers to innovation activities, importance of suppliers outside local area to innovation activities, importance of clients and customers to innovation activities) the significant variables previously discussed from Table 6.8, all remained significant. In addition to these variables, two out of the three network variables were significant and the labour variable also became significant in the primary regression with dependent variable *INNOV*.

Previous literature stated that most innovation in food processing originates outside of the firm and that the knowledge spills-over from other industries and business. The network variables seem to support this literature. With *INNOV* as the dependent variable, this model explained 51 percent of the factors that influence a firm's decision to innovate.

Also interesting to note, a one standard deviation change for the population within 100 km of the firm will increase the probability of a firm innovating by 16.4 percent.

The clients and customers of a firm were of consequence to their innovation activities. Whether the knowledge for the innovation came from them, or that the clients and customers asked the firm to innovate and the knowledge came from elsewhere, this relationship was important to firm's introducing innovation.

The additional network variables were also significant in the second regression with the dependent variable *INNMKT*. The addition of these variables did not improve the significance of any other variables in this model, nor did the make any more variables significant in the third regression where the dependent variable is *INNBUS*. Table 6.9 shows the results for the three regressions with the addition of the excluded step wise variables

Table 6.9 – Probit Model: Step Wise Selected Variables with Added Network Variables

Dependent Variable	**INNOV**	**INNMKT**	**INNBUS**
Independent Variable		**Coefficient (Standard Error)**	
Importance of local suppliers (within 100 km) to business's innovation activities	-.6723* (.3482)	-.2697** (.1250)	.0785 (.1406)
Importance of suppliers outside local area to business's innovation activities	-.3566 (.3009)	.2772** (.1269)	-.1724 (.1604)
Importance of clients and customers to business's innovation activities	.7645** (.3709)	.2740** (.1256)	.0494 (.1334)
Sell products in local market	-.0297** (.0137)	-.0027 (.0070)	-.0127* (.0069)
Sell products in U.S.	.0056 (.0138)	.0195** (.0086)	.0075 (.0115)
Business is privately owned	.1770 (.7677)	.6803 (.5634)	.5530 (.5570)
# of employees in 2004	.0314* (.0159)	.0021 (.0018)	.0142* (.0086)
Population within 100 km of firm	2.72e-06** (1.17e-06)	2.49e-07 (4.42e-07)	8.57e-07 (5.75e-07)
Population within 100 to 200 km of firm	6.66e-07 (5.78e-07)	-2.66e-08 (2.97e-07)	2.16e-07 (3.85e-07)
Population within 200 to 300 km of firm	2.50e-07 (6.14e-07)	-2.84e-07 (2.95e-07)	1.64e-07 (4.29e-07)
Population within 300 to 400 km of firm	1.55e-06** (6.63e-07)	2.48e-07 (3.15e-07)	8.34e-07** (3.75e-07)
Distance to Winnipeg (km)	.0203** (.0082)	.0002 (.0026)	.0097** (.0049)
Distance to Regina (km)	-.0088** (.0041)	-.0012 (.0017)	-.0023 (.0021)
Distance to Vancouver (km)	.0218** (.0084)	-.0003 (.0027)	.0110** (.0050)
Effect lack of labour available locally (within 100 km) had on competitiveness of firm	-.5276** (.2609)	-.1145 (.1364)	-.0806 (.1397)
Year of establishment of business	.0530** (.0246)	-.0066 (.0104)	.0269** (.0131)

*, **, *** denote significance at 10 percent, 5 percent and 1 percent levels respectively.

6.6 Hypotheses Testing

At the outset of this thesis, the objective was to examine characteristics of firms that were innovating in the food processing industry in Western Canada, and determine if locating in an urban or rural region affected innovation activities. A wealth of data and information has been collected and evaluated, and it is important to bring the discussion back to the motivation for this research and address the specific hypotheses of this thesis:

> *Firms with an extensive network of suppliers and clients will be less likely to introduce innovation.*

This hypothesis is rejected. The network of a firm appears to play an important role in the innovation activities of a firm. It does not seem to be the suppliers that are the most important to firm's innovation activities; clients and customers increase the probability that firms will introduce innovation.

The following null hypothesis: *Firms exporting products outside of their local market will have a small probability of participating in innovation activities* is also rejected. The results indicate that firms exporting outside of their local market have a higher probability of introducing innovation into the market, their business or both. These variables were consistently significant across the various models. This could be due to firms competing in a larger market must innovate to remain competitive in the market, and experience long run growth.

The null hypothesis that access to markets does not affect probability that firms will participate in innovation activities is also rejected. The results indicate that that access to markets increases the probability that food processing firms in Western Canada will participate in innovation activities. The variables measuring population within a 200 km radius of the firm were consistently significant throughout the various models, while the variables measuring population between a 200 and 400 km radius were frequently significant.

Innovation activities of food processing firms will not depend on the region where the firm is located. The impact on innovation activity from where a firm locates is unclear. The regional dummy variables that were included in the models were insignificant in the step wise analysis. The variables accounting for distance to urban centers are significant for the cities of Winnipeg, Vancouver and Regina. The probability of firm's introducing innovation increases the greater the distance they are from Winnipeg and Vancouver, contradicting the results presented for market access. One suggestion proposed to explain this inconsistency is that some outliers exist in the data, and they are skewing the results.

By combining some of the hypotheses test results listed above, there may be some small insight into the rural vs. urban location debate regarding innovation and food processors. It was established that access to markets, the network of clients and customers to a firm and the market final goods product of a firm are important factors for innovative activity. It could be established that with innovative firms selling outside their regional market, their clients and customers are located outside of the regional market (100 km radius).

While the population within 200 km of the firm was the most significant, the population within 400 km was also frequently significant. Combining these results may suggest that rural firms within 400 km of a large population are more likely to participate in innovative activity, therefore improving their long run competitiveness. While none of the results specifically indicate if urban firms have an advantage over rural firms with regards to innovative activity, the combination of these results suggests that remote rural firms will be at a disadvantage to introduce innovations.

6.7 Chapter Summary

In this chapter, the results of the econometric analysis examining the characteristics of firm's that are innovating in the food processing industry in Western Canada were presented and critically analyzed. The results of the two different empirical approaches are discussed and then the hypotheses of this thesis are discussed using these results. The results highlight the fact that market access and firm attributes, such as size and age of the firm, play an important role in the innovation activities of food processing firms. The next chapter concludes the thesis with a brief summarization of the results, and a discussion of the policy implications of this research.

Chapter 7: Conclusions

7.0 Introduction

The purpose of this chapter is to present conclusions based on the results and analysis of this thesis. First, a summary of the results is provided in conjunction with relevant policy implications of this research. This is followed by a brief discussion of the limitations of the study. The chapter concludes with possible recommendations for future research and indicates how this thesis adds to the current literature.

7.1 Conclusions and Policy Implications

I rejected the two null hypotheses of this thesis—i.e., whether the decision of food processing to participate in innovation activities was affected by market access and by the region where they are located. Market access variables were statistically significant in explaining innovation activities in firms. Region variables were not statistically significant, but some regional policy implications can be suggested because of the statistical significance of the market access variables.

Market access was a determining factor in the innovation activities of food processing firms in Western Canada. This study found that access to a large population within a 200 km radius was important to the innovation activities of firms. Population within a 200 to 400 km radius of a firm was also statistically significant in a number of cases. Specific provinces or regions within Western Canada were not statistically significant in the data analysis, but the market access variables help define the urban versus rural region question as it applies to innovation activities of food processors.

These results indicate that creating and implementing innovation is more difficult in remote rural areas, than areas close to an urban center. While not impossible to implement innovation in a remote rural area, innovation is much more likely to occur in firms with access to the firm and household amenities offered by a large population. These amenities include business services such as accountants, lawyers and suppliers. It also includes access to a large labour market, which offers a greater number of skilled workers.

Access to a large population offers access to other industries and firms. Previous literature identified the importance of knowledge spillovers for firms in the food processing industry. By locating near a large population, food processing firms have the potential to benefit from the knowledge spillover of the surrounding industries, therefore increasing the probability that the food processing firm will innovate.

Remote rural regions are at a significant disadvantage with respect to knowledge spillovers. Food processing firms located in rural areas on the fringes of an urban area are able to benefit from knowledge spillovers, access to labour and business services and potentially have greater access to raw materials and lower land costs.

Some of the firm attribute variables were also statistically significant, and increased the probability that food processing firms would innovate. New firms were more likely to introduce innovation. This is most likely due to new firms trying to capture market share in a competitive market and extend the life of their firm. This is consistent with the statistical significance of firms participating in innovation if they sold goods outside of their local market. Competition stimulates innovation in food processing firms.

Larger firms were also more likely to innovate. Once again access to a large market plays a role. Larger firms will need access to more employees than smaller firms. Proximity to a bigger population increases the potential labour pool for firms, and offers more skilled workers.

With these results, future policy with regards to innovation in food processing should be directed at developing an open, competitive market where firms have access to export opportunities outside of their local market. Food processing firms can benefit greatly from knowledge spillovers therefore public funds should not necessarily be directed at specific firms, but more at specific products or processes. A competitive market with access to knowledge spillovers and a large market stimulate innovation activity within food processors in Western Canada.

7.2 Limitations of the Research

There are several limitations of this study. One weakness is the number of observations. With the limited number of food processors in Western Canada, it was difficult to obtain a larger number of completed surveys. With more observations, some other characteristics may have become statistically significant in the step wise analysis, or stronger results may have come forth for the principle component analysis. .

Another limitation for this analysis was that some of the distance variables for cities with population over 100,000 were highly correlated. The collinearity between these variables makes it difficult to determine the individual influence of each individual variables, or which variables had the most influence on the results.

There are also potential limitations due to the variables used in this study. While every effort was made to include variables that best measured the factors that influence innovation activities in firms, undoubtedly there were variables missing from this analysis that could help explain the innovation decisions of food processing firms. It is very difficult to account for the "intangible" characteristics of a firm such as the entrepreneurial spirit or acceptance of innovative ideas within a firm.

7.3 Recommendations for Future Research

Research on the food processing industry in Canada is very limited and is open to a variety of opportunities. Continued work on the distribution of the questionnaire to food processors in Eastern Canada would result in a comprehensive study on innovation, location and firm characteristics of food processors across Canada. From this, further work could be conducted to link innovation with region and firm characteristics and location. Research could also be conducted to measure the level of innovative activity within a firm.

Investigation could be completed on the markets firms are exporting to, and how trade regulations (provincially, nationally and internationally) are affecting firm's innovation activities. While this was not investigated in this thesis, comments from survey respondents indicated regulations were a limiting factor in their innovation activities, and their decision to export products.

Future work could also be done on knowledge spillovers in the food processing industry. Strong evidence exists that the majority of innovations introduced in the food processing industry originate outside the industry. Therefore, examining the origin of these knowledge spillovers would be interesting. The results could influence research and development activities of food processing firms, and better target policy for innovation in the food processing industry.

7.4 Conclusion

World wide growth in the food processing industry has stagnated. Innovation has been proposed as the key to the revitalization of the food processing industry, because it potentially increases long run growth and competitiveness of firms. The factors that influence innovation activity in food processing firms in Western Canada have been researched and discussed in this thesis. This was the first research to link spatial variables with firm characteristics and innovation in the food processing industry in Canada. While this study has its limitations, it provides some initial insight into the innovation activities of food processors in Western Canada.

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Appendix A: Innovation Survey

1. For regional identification, please provide the first three digits of your postal code ☐☐☐

2. What year was your business established? ____________

3. Is your business privately owned? Yes ☐ Other (please specify)__________________________

Is your business a foreign affiliate/partner of a Multinational Enterprise (MNE)? A foreign affiliate is when the MNE has an ownership/equity of 10% or greater. **Yes ☐ No ☐**

Is your business a parent for an affiliate in a foreign country? Yes ☐ No ☐

4. Does your business provide contract services to other firms or organizations? Yes ☐ No ☐

5. Do other firms or organizations provide contract services to your business? Yes ☐ No ☐

If yes, list the types of contracted services and the reasons why you contract out.

____

____

6. What products do you produce? Please rank the top three based on sales volume.

_______________________ _______________________ _______________________

7. In which geographic markets did your business SELL and PURCHASE goods or services during the three years 2002 to 2004?

	Percentage Total SALES	**Percentage Total PURCHASES**
Local (within 100 kms)	______%	______%
Regional (within province)	______%	______%
National (outside of province)	______%	______%
United States	______%	______%
All other countries (except US)	______%	______%

8. If your business exports, please rank the top three countries based on sales revenue.

_______________________ _______________________ _______________________

9. If your business does not export please indicate why (choose as many answers as are appropriate).

Lack of market information ☐
Product/service not appropriate for exporting ☐
Not able to meet standards/regulations necessary for export market ☐
Trade barriers ☐
Not able to compete in export market ☐
Too risky ☐ Other ________________

Definitions (to use with Question 10)

Product Innovation: Introduction of a new, or significantly improved, good or service (eg. improved software in equipment). Innovation may be new to your industry or market or new to your business only.
Process Innovation: Implementation of a new or significantly improved production process, distribution method or support activity for your good or services. Innovation may be new to your industry or market or new to your business only

10. During the three years 2002 to 2004, did your enterprise introduce:

	Yes: New to your business	Yes: New to your market	No
Product Innovation			
New of significantly improved goods.	☐	☐	☐
Process Innovation			
New or significantly improved methods of manufacturing or producing goods or services	☐	☐	☐
New or significantly improved services	☐	☐	☐
A major change to the organization of work within your business such as changes to management structure or integrating different departments or activities	☐	☐	☐
New or significantly improved logistics, delivery or distribution methods for your inputs, goods or services	☐	☐	☐
Other (please specify) ______________________________	☐	☐	☐

11. If you are a parent company of a foreign affiliate, did you supply your foreign affiliate with innovations? Yes ☐ No ☐

If yes, what was the estimated R&D value associated with the adopted innovation? $_________ ☐ Don't know

We are now trying to understand your research expenditures on a number of innovation activities.

12. During the three years 2002 to 2004, did your business undertake the following innovation activities?

		Yes	Estimated Average Expenditure over 3 years	OR	Percentage of Total Expenditure
Intramural (in-house) R&D	R&D linked to new or significantly improved goods or services or processes carried out **within** your business	☐	$	**OR**	%
Extramural R&D	Same activities as above, but performed by other businesss or by public or private research organisations and purchased by your business	☐	$	**OR**	%
Acquisition of machinery, equipment and software	Acquisition of advanced machinery, equipment and computer hardware or software purchased specifically to produce new or significantly improved products and processes	☐	$	**OR**	%
Acquisition of other external knowledge	Purchase or licensing of patents and non-patented inventions, know-how, trademarks, and other types of knowledge from other businesss or organisations for the development of new or significantly improved products or processes	☐	$	**OR**	%
Training	Internal or external training for your personnel specifically for the development and/or introduction of new or significantly improved products and processes	☐	$	**OR**	%
Market introduction of innovations	Activities for the market introduction of your new or significantly improved goods and services, including market research and launch advertising	☐	$	**OR**	%
Other preparations	Procedures and technical preparations to implement new or significantly improved products and processes that are not covered elsewhere.	☐	$	**OR**	%

13. During the three years 2002 to 2004, how important to your business's innovation activities were each of the following as a source of information or new ideas? Please also indicate if they worked with you on the innovation activities.

		Degree of importance						Worked with you
		Not Important				Very Important	Not used	
		1	2	3	4	5		
Internal	Research and Development Staff	1	2	3	4	5	☐	N/a
	Other business units of your business	1	2	3	4	5	☐	N/a
Market sources	Suppliers of equipment, materials, components, or software within local (100 km) area	1	2	3	4	5	☐	☐
	Suppliers of equipment, materials, components, or software outside local (100 km) area	1	2	3	4	5	☐	☐
	Clients or customers	1	2	3	4	5	☐	☐
	Competitors or other enterprises within your local (100 km) area	1	2	3	4	5	☐	☐
	Competitors or other enterprises outside your local (100 km) area	1	2	3	4	5	☐	☐
	Consultants, commercial labs, or private R&D institutes	1	2	3	4	5	☐	☐
Institutional sources	Universities or other higher education institutions	1	2	3	4	5	☐	☐
	Government or public research institutes	1	2	3	4	5	☐	☐
Other sources	Conferences, trade fairs, exhibitions	1	2	3	4	5	☐	**N/a**
	Scientific journals and trade/technical publications	1	2	3	4	5	☐	**N/a**
	Professional and industry associations	1	2	3	4	5	☐	☐

If your business has introduced product or process innovations during the three years 2002 to 2004, please answer questions 14, 15, and 16, otherwise skip to question 17.

	Mainly your business	Your parent MNE or Your foreign Affiliate	Your business together with other businesss or institutions	Mainly other **private** businesss or institutions (eg. consultant or private lab)	Mainly other **public** businesss or institutions (eg University)
14. Who developed the product innovations?	☐	☐	☐	☐	☐
15. Who developed the process innovations?	☐	☐	☐	☐	☐

16. What degree of impact did new or significantly improved goods/services or processes developed and introduced during the three year period between 2002 and 2004 have on your business?

		Degree of impact: Low Impact				High Impact	Not relevant
Product oriented effects	Increased range of goods or services	1	2	3	4	5	☐
	Entered new domestic markets or increased market share	1	2	3	4	5	☐
	Improved quality of goods or services	1	2	3	4	5	☐
	Entered new international markets or increased market share	1	2	3	4	5	☐
	Allowed business to keep up with competitors	1	2	3	4	5	☐
Process oriented effects	Increased capacity of production or service provision	1	2	3	4	5	☐
	Reduced labour costs per unit output	1	2	3	4	5	☐
	Reduced materials and energy per unit output	1	2	3	4	5	☐
	Improved inventory management	1	2	3	4	5	☐
Other effects	Met regulatory requirements	1	2	3	4	5	☐

17. During the three years 2002 to 2004, how damaging were the following factors for hampering your INNOVATION activities or projects or influencing a decision not to innovate?

		Degree of damage: Not Damaging				Very Damaging	Factor not experienced
Cost factors	Lack of funds within your business	1	2	3	4	5	☐
	Lack of financing options from sources outside your business	1	2	3	4	5	☐
Knowledge factors	Lack of trained <u>local</u> (within 100 kms) labour force	1	2	3	4	5	☐
	Lack of qualified labour force available (anywhere)	1	2	3	4	5	☐
	Lack of information on technology	1	2	3	4	5	☐
	Lack of information on markets	1	2	3	4	5	☐
	Lack of information on potential partners	1	2	3	4	5	☐
	Difficulty in finding cooperation partners for innovation	1	2	3	4	5	☐
	Lack of industry-wide standards	1	2	3	4	5	☐
Market factors	Market dominated by established businesss	1	2	3	4	5	☐
	Uncertain demand for innovative goods or services	1	2	3	4	5	☐
	Risk related to feasibility of innovative goods or services	1	2	3	4	5	☐
	Government policy regulations hampering product development and/or marketing	1	2	3	4	5	☐
	Location of your business	1	2	3	4	5	☐
	Lack of regulatory protection for innovative goods or services	1	2	3	4	5	☐
	Lack of access to airports or rail service	1	2	3	4	5	☐
	Lack of adequate road system	1	2	3	4	5	☐
Reasons not to innovate	No need due to prior innovations	1	2	3	4	5	☐
	No need because of no demand for innovations	1	2	3	4	5	☐

We are trying to understand the relationship between innovation and competitiveness so now we are asking the question again in terms of about how important you believe these factors are to making you competitive in your industry.

18. During the three years 2002 to 2004, how damaging were the following factors for hampering your COMPETITIVENESS within your industry?

		Degree of damage					
		Not Damaging				Very Damaging	Factor not experienced
Cost factors	Lack of funds within your business	1	2	3	4	5	☐
	Lack of financing options from sources outside your business	1	2	3	4	5	☐
Knowledge factors	Lack of trained <u>local</u> (within 100 kms) labour force	1	2	3	4	5	☐
	Lack of qualified labour force available (anywhere)	1	2	3	4	5	☐
	Lack of information on technology	1	2	3	4	5	☐
	Lack of information on markets	1	2	3	4	5	☐
Market factors	Market dominated by established businesss	1	2	3	4	5	☐
	Government policy regulations hampering product development and/or marketing	1	2	3	4	5	☐
	Lack of regulatory protection for innovative goods or services	1	2	3	4	5	☐
	Location of your business	1	2	3	4	5	☐
	Lack of access to airports	1	2	3	4	5	☐
	Lack of access to railroad	1	2	3	4	5	☐
	Lack of adequate road system	1	2	3	4	5	☐
	Lack of access to broadband technologies	1	2	3	4	5	☐

19. During the three years 2002 to 2004, did your business:

	Yes	No
Apply for a patent	☐	☐
Register an industrial design	☐	☐
Register a trademark	☐	☐
Claim copyright	☐	☐

20. During the three years 2002 to 2004 did your business use any of the following types of programs sponsored by the federal or provincial governments?

	Federal Government	Provincial Government	Did not use government program
Research and Development tax credits	☐	☐	☐
Government research and development grants	☐	☐	☐
Government venture capital support	☐	☐	☐
Government technology support and assistance programs	☐	☐	☐
Government information or internet services	☐	☐	☐
Government support for training	☐	☐	☐
Other government support programs (please specify) ______________________________	☐	☐	☐

21. What was the number of full time equivalent (FTE) staff employed by your business?

2002 _________________ 2003______________________ 2004______________________

22. Were you born locally (within 100km of the business's location)**?**

☐ **Yes** ☐ **No**

If Yes, have you lived here all your life?

☐ **Yes** ☐ **No;** what proportion of your adult life have you lived here? ____________________%

23. Are you the manager of this business or of a research and development department within the business?

☐ Yes, General Manager

☐ Yes, Manager of Research and Development

☐ No, I am neither of the above

24. Please indicate your highest level of education?

☐Less than high school ☐High school graduate ☐Post- secondary degree or diploma

25. What was your business's total revenue for the three years 2002 to 2004?

2002	0 - $250,000	$250,000 - $1m	$1m - $2m	$2m - $5m	$5m - $10m	over $10 million
2003	0 - $250,000	$250,000 - $1m	$1m - $2m	$2m - $5m	$5m - $10m	over $10 million
2004	0 - $250,000	$250,000 - $1m	$1m - $2m	$2m - $5m	$5m - $10m	over $10 million

(If applicable) **What was your parent MNE's total revenue for the three years 2002 to 2004?**

2002	0 - $250,000	$250,000 - $1m	$1m - $2m	$2m - $5m	$5m - $10m	over $10 million
2003	0 - $250,000	$250,000 - $1m	$1m - $2m	$2m - $5m	$5m - $10m	over $10 million
2004	0 - $250,000	$250,000 - $1m	$1m - $2m	$2m - $5m	$5m - $10m	over $10 million

(If applicable) **What was your foreign affiliate(s) total revenue for the three years 2002 to 2004?**

2002	0 - $250,000	$250,000 - $1m	$1m - $2m	$2m - $5m	$5m - $10m	over $10 million
2003	0 - $250,000	$250,000 - $1m	$1m - $2m	$2m - $5m	$5m - $10m	over $10 million
2004	0 - $250,000	$250,000 - $1m	$1m - $2m	$2m - $5m	$5m - $10m	over $10 million

Appendix B: Variable Definition and Descriptive Statistics

Table B-1: Variable Name, Description, Source and Mean

Variable Name	Variable Description	Data Source	Mean
innov	Firm introduced innovation to their market, business or both between 2002 – 2004	Innovation Survey	.8396
innmkt	Firm introduced innovation to their market between 2002 – 2004	Innovation Survey	.4245
innbus	Firm introduced innovation to their business between 2002 - 2004	Innovation Survey	.7736
pop_100	Population within 100 kms of firm	C-RERL	1065107
pop_100_200	Population between 100 and 200 kms of firm	C-RERL	1065601
pop_200_300	Population between 200 and 300 kms of firm	C-RERL	1567464
pop_300_400	Population between 300 and 400 kms of firm	C-RERL	1366965
pop_400_500	Population between 400 and 500 kms of firm	C-RERL	1603406
pop_500_600	Population between 500 and 600 kms of firm	C-RERL	1409579
pop_600_700	Population between 600 and 700 kms of firm	C-RERL	1770120
pop_700_800	Population between 700 and 800 kms of firm	C-RERL	1991007
tb_km	Distance to Thunder Bay (km)	C-RERL	1841.094
wpeg_km	Distance to Winnipeg (km)	C-RERL	1254.132
reg_km	Distance to Regina (km)	C-RERL	866.2356
stoon_km	Distance to Saskatoon (km)	C-RERL	764.2243
calg_km	Distance to Calgary (km)	C-RERL	583.2714
rdeer_km	Distance to Red Deer (km)	C-RERL	591.8063
edm_km	Distance to Edmonton (km)	C-RERL	633.4528
abbot_km	Distance to Abbotsford (km)	C-RERL	673.6468
lang_km	Distance to Langley (km)	C-RERL	681.602
surr_km	Distance to Surrey (km)	C-RERL	688.84
rich_km	Distance to Richmond (km)	C-RERL	699.6309
van_km	Distance to Vancouver (km)	C-RERL	697.0534
burn_km	Distance to Burnaby (km)	C-RERL	690.5066
gvan_km	Distance to Greater Vancouver (km)	C-RERL	692.5938
saan_km	Distance to Saanich (km)	C-RERL	745.8318
vic_km	Distance to Victoria (km)	C-RERL	748.5074
okan_km	Distance to Okanogan (km)	C-RERL	598.903
seattle_km	Distance to Seattle (km)	C-RERL	769.4456
minn_km	Distance to Minneapolis (km)	C-RERL	1747.548
denv_km	Distance to Denver (km)	C-RERL	1589.625
sell_local	Sell goods to local market (within 100 km of firm)	Innovation Survey	29.6982
sell_reg	Sell goods to regional market (outside 100 km of firm)	Innovation Survey	28.5680
sell_nat	Sell goods to national market	Innovation Survey	17.4125
sell_us	Sell goods to U.S. market	Innovation Survey	14.9786
sell_oth	Sell goods to other international markets	Innovation Survey	7.5116

Table B -1 continued on next page

cmp_lk_lbr_loc	Degree to which lack of trained local (within 100 kms) labour force had on hampering business's competitiveness within industry	Innovation Survey	2.2642
cmp_lk_lbr_out	Degree to which lack of qualified labour force available anywhere had on hampering business's competitiveness within industry	Innovation Survey	2.2642
imp_rd_staff	Importance of research and development staff to business's innovation activities Importance of research and development staff to innovation activities of firm	Innovation Survey	2.1981
dmg_lk_lbr_loc	Degree of damage lack of trained local (within 100 kms) labour force had on innovation activities or projects Damage lack of labour available locally (within 100 km) had on innovation activities	Innovation Survey	2.2264
dmg_lk_lbr_out	Degree of damage on business's innovation activities or projects from lack of qualified labour force available anywhere	Innovation Survey	2.1415

imp_supp_loc	Importance of local suppliers (within 100kms) of equipment, materials, components or software to business's innovation activities	Innovation Survey	2.0943
imp_supp_out	Importance of suppliers (outside 100kms) of equipment, materials, components or software to business's innovation activities	Innovation Survey	2.7547
imp_cli_cust	Importance of clients or customers to business's innovation activities	Innovation Survey	3.4245
imp_comp_loc	Importance of local competitors (within 100 kms) business's innovation activities	Innovation Survey	1.3962
imp_comp_out	Importance of competitors or other enterprises outside local area (outside 100kms) to business's innovation activities	Innovation Survey	1.8584
imp_cons_priv	Importance of consultants, commercial labs or private R&D institutes to business's innovation activities	Innovation Survey	1.6981
imp_un	Importance of universities or other higher education institutions to business's innovation activities	Innovation Survey	1.5283
imp_govt_pub	Importance of government or public research institutes to business's innovation activities	Innovation Survey	1.9906
imp_conf_exh	Importance of conferences, trade fairs, exhibitions to business's innovation activities	Innovation Survey	2.5943
imp_jnl_pubs	Importance of scientific journals and trade/technical publications to business's innovation activities	Innovation Survey	1.8491
imp_assoc	Importance of professional and industry associations to business's innovation activities	Innovation Survey	2.3302

Table B-1 continued on next page

bc_dm	Regional identification variable for British Columbia	C-RERL	.4622
ab_dm	Regional identification variable for Alberta	C-RERL	.2452
sk_dm	Regional identification variable for Saskatchewan	C-RERL	.1604
mb_dm	Regional identification variable for Manitoba	C-RERL	.1321
dmg_loc_bus	Degree of damage to business's innovation activities due to location of business	Innovation Survey	2.1226
dmg_lk_apt	Degree of damage to business's innovation activities due to lack of access to airports or rail service for business	Innovation Survey	1.1604
dmg_lk_rd	Degree of damage to business's innovation activities due to lack of access to adequate road system	Innovation Survey	1.1604

year	Year of establishment	Innovation Survey	1986
priv	Privately owned business	Innovation Survey	.8585
mne	Affiliation with a multinational enterprise	Innovation Survey	.1038
emp_02	Number of employees 2002	Innovation Survey	30.4717
emp_03	Number of employees 2003	Innovation Survey	32.5094
emp_04	Number of employees 2004	Innovation Survey	36.5943
rev_02	Revenue of firm 2002	Innovation Survey	2.2264
rev_03	Revenue of firm 2003	Innovation Survey	2.3208
rev_04	Revenue of firm 2004	Innovation Survey	2.5189
exp_int_rd	Expenditure on in-house R&D	Innovation Survey	88519.2
exp_ext_rd	Expenditure on extramural R&D	Innovation Survey	7363.21
exp_mchn	Expenditure on acquired machinery, equipment and software to produce new or improved products	Innovation Survey	67334.43
exp_ext_knl	Expenditure on acquired other external knowledge to develop new or improved products	Innovation Survey	6957.547
exp_trn	Expenditure of training for personnel for the development or introduction of new or improved products	Innovation Survey	11331.13
exp_oth_inn	Expenditure on other preparations to implement innovation	Innovation Survey	11537.74
dmg_lk_fnd	Degree of damage lack of funds within business had on innovation activities or projects	Innovation Survey	2.8773
dmg_lk_fin	Degree of damage lack of financing options from sources outside business had on innovation activities or projects	Innovation Survey	2.2642
imp_oth_bus	Importance of other business units within business to business's innovation activities	Innovation Survey	1.6604

Table B-1 continued on next page

ip_rng_gs	Impact increased range of goods or services had on business	Innovation Survey	2.1321
ip_dm_mkt	Impact from entering new domestic market or increased market share had on business	Innovation Survey	2.0755
ip_qlt_gs	Impact improved quality of goods or services had on business	Innovation Survey	2.3019
ip_intl_mkt	Impact from entering new international markets or increased market share had on business	Innovation Survey	1.2642
ip_bus_comp	Impact new or significantly improved products had on business keeping up with competitors	Innovation Survey	2.2830
ip_inc_cap	Impact increased capacity of production or service provision had on business	Innovation Survey	2.3585
ip_rd_lbr_cst	Impact reduced labour costs (per unit output) from improved processes had on business	Innovation Survey	1.8302
ip_rd_mat	Impact reduced materials and energy (per unit output) from improved processes had on business	Innovation Survey	1.5943
ip_inv_mgt	Impact improved inventory management from improved processes had on business	Innovation Survey	1.4717
ip_reg_rqt	Impact on business from meeting regulatory requirements through new goods/services or processes	Innovation Survey	1.7170
dmg_pr_inn	Degree of damage to business's innovation activities because there was no need to innovate due to prior innovations	Innovation Survey	.9434
dmg_no_dmd	Degree of damage to business's innovation activities because there was no demand for innovations	Innovation Survey	1.0187

Appendix C – Principle Component Analysis

This section has displays the eigenvectors calculated for each factor. As shown, the regional variables and the firm attribute variables have the lowest cumulative variance explained. The last table in this section shows the regression results of the PCA variables on the dependent variables *INNOV*, *INNMKT* and *INNBUS*.

Table C-1: Principal Component Eigenvectors: Market Access

Market Access Variables	**Eigenvectors**
Population within 100 km of firm	-0.1447
Population within 100 to 200 km of firm	-0.1476
Population within 200 to 300 km of firm	-0.1586
Population within 300 to 400 km of firm	-0.1448
Population within 400 to 500 km of firm	-0.1525
Population within 500 to 600 km of firm	-0.0370
Population within 600 to 700 km of firm	0.0520
Population within 700 to 800 km of firm	0.0208
Distance to Thunder Bay (km)	-0.2322
Distance to Winnipeg (km)	-0.2318
Distance to Regina (km)	-0.2085
Distance to Saskatoon (km)	-0.1772
Distance to Calgary (km)	0.0779
Distance to Red Deer (km)	0.0497
Distance to Edmonton (km)	0.0171
Distance to Abbotsford (km)	0.2351
Distance to Langley (km)	0.2354
Distance to Surrey (km)	0.2356
Distance to Richmond (km)	0.2357
Distance to Vancouver (km)	0.2357
Distance to Burnaby (km)	0.2357
Distance to Greater Vancouver (km)	0.2357
Distance to Saanich (km)	0.2356
Distance to Victoria (km)	0.2356
Distance to Okanogan (km)	0.2190
Distance to Seattle (km)	0.2347
Distance to Minneapolis (km)	-0.2290
Distance to Denver (km)	-0.1743
Sell goods to local market (within 100 km of firm)	-0.0353
Sell goods to regional market (outside 100 km of firm)	-0.0382
Sell goods to national market	-0.0509
Sell goods to U.S. market	0.0009
Sell goods to other international markets	0.0388
Cumulative Variance Explained	*54.07%*

Table C-2: Principal Component Eigenvectors: Labour Market Variables

Labour Market Variables	**Eigenvectors**
Degree to which lack of trained local (within 100 kms) labour force had on hampering business's competitiveness within industry	0.4956
Degree to which lack of qualified labour force available anywhere had on hampering business's competitiveness within industry	0.4945
Importance of research and development staff to business's innovation activities Importance of research and development staff to innovation activities of firm	0.1603
Degree of damage lack of trained local (within 100 kms) labour force had on innovation activities or projects Damage lack of labour available locally (within 100 km) had on innovation activities	0.4879
Degree of damage on business's innovation activities or projects from lack of qualified labour force available anywhere	0.4961
Cumulative Variance Explained	*64.63%*

Table C-3: Principal Component Eigenvectors: Network Variables

Network Variables	**Eigenvectors**
Importance of local suppliers (within 100 km) to firm's innovation activities	0.2770
Importance of suppliers (outside 100 km) to firm's innovation activities	0.2215
Importance of clients and customers to firm's innovation activities	0.3346
Importance of local competitors (within 100 km) to firm's innovation activities	0.2763
Importance of competitors (outside 100 km) to firm's innovation activities	0.2828
Importance of consultants and private research institutions to firm's innovation activities	0.3083
Importance of universities to firm's innovation activities	0.2842
Importance of government publications to firm's innovation activities	0.3285
Importance of conferences and exhibitions to firm's innovation activities	0.2899
Importance of journal publications to firm's innovation activities	0.3435
Importance of industry associations to firm's innovation activities	0.3467
Cumulative Variance Explained	*39.89%*

Table C-4: Principal Component Eigenvectors: Regional Variables

Regional Variables	**Eigenvectors**
Regional identification for British Columbia	-0.0173
Regional identification for Alberta	-0.0987
Regional identification for Saskatchewan	-0.0422
Regional identification for Manitoba	0.1966
Degree of damage to business's innovation activities due to location of business	0.5948
Degree of damage to business's innovation activities due to lack of access to airports or rail service for business	0.6147
Degree of damage to business's innovation activities due to lack of access to adequate road system	0.4668
Cumulative Variance Explained	*26.57%*

Table C-5: Principal Component Eigenvectors: Firm Attribute Variables

Firm Attribute Variables	Eigenvectors
Year of establishment	-0.1482
Firm is privately owned	-0.2377
Firm is affiliated with a multinational enterprise	0.1295
Number of employees in 2002	0.3635
Number of employees in 2003	0.3573
Number of employees in 2004	0.3540
Revenue of firm in 2002	0.3786
Revenue of firm in 2003	0.3766
Revenue of firm in 2004	0.3596
Undertook in-house R&D	0.1555
Undertook extramural R&D	0.18877
Acquired machinery, equipment and software to produce new or improved products	0.0838
Acquired other external knowledge to develop new or improved products	0.0618
Training for personnel for the development or introduction of new or improved products	0.1460
Other preparations to implement innovation	0.1154
Cumulative Variance Explained	*32.40%*

Table C-6: Principal Component Eigenvectors: Competitive Conditions Variables

Competitiveness Variables	Eigenvectors
Impact increased range of goods or services had on business	0.3236
Impact from entering new domestic market or increased market share had on business	0.3039
Impact improved quality of goods or services had on business	0.3489
Impact from entering new international markets or increased market share had on business	0.2684
Impact new or significantly improved products had on business keeping up with competitors	0.3351
Impact increased capacity of production or service provision had on business	0.3388
Impact reduced labour costs (per unit output) from improved processes had on business	0.3173
Impact reduced materials and energy (per unit output) from improved processes had on business	0.3134
Impact improved inventory management from improved processes had on business	0.2951
Impact on business from meeting regulatory requirements through new goods/services or processes	0.3093
Degree of damage to business's innovation activities because there was no need to innovate due to prior innovations	0.0229
Degree of damage to business's innovation activities because there was no demand for innovations	0.0249
Cumulative Variance Explained	*51.94%*

Table C-7: Selected Regression Results for PCA Variables

Dependent Variable	**INNOV**	**INNMKT**	**INNBUS**
Independent Variable		**Coefficient (Standard Error)**	
Market Access	-7.48e-08	2.10e-08	-4.59e-08
	(2.00e-07)	(1.67e-07)	(1.86e-07)
Labour Market Access	.0015	-.0095	.0166
	(.0567)	(.0480)	(.0532)
Network of Firm	.0305	.0379	.0052
	(.0431)	(.0374)	(.0401)
Regional Characteristics	.0371	.0521	.0914
	(.0936)	(.0753)	(.0892)
Firm Attributes	.0041	.0017	.0026
	(.0046)	(.0015)	(.0031)

*, **, *** denote significance at 10 percent, 5 percent and 1 percent levels respectively.

Appendix D: Selected Variables for Benchmark Model

Table D-1 shows the variables used in the specification of the benchmark model. The majority of these variables were selected by step wise analysis. The addition of the other variables was due to the trends that emerged during the step wise analysis. The incremental addition and subtraction of these variables resulted in the specification of the final benchmark model.

Table D-1: Variables Used in Specification of Benchmark Model

Dependent Variable	**INNOV**	**INNMKT**	**INNBUS**
Independent Variable		**Coefficient (Standard Error)**	
Population within 100 to 200 km of firm	7.98e-07* (4.68e-07)	-7.72e-10 (2.79e-07)	2.26e-07 (3.66e-07)
Population within 200 to 300 km of firm	7.83e-07 (5.43e-07)	-8.54e-08 (2.78e-07)	8.94e-08 (3.74e-07)
Population within 300 to 400 km of firm	8.52e-07* (4.46e-07)	3.55e-07 (2.89e-07)	7.52e-07** (3.56e-07)
Population within 400 to 500 km of firm			
Sell goods in regional market			
Sell goods in local market			
Sell goods in U.S. market			
Distance to Saskatoon (km)			
Distance to Calgary (km)			
Distance to Abbotsford (km)			
Distance to Winnipeg (km)	.0120** (.0057)	.0008 (.0026)	.0092* (.0049)
Distance to Regina (km)	-.0055* (.0030)	-.0018 (.0016)	-.0017 (.0019)
Distance to Vancouver (km)	.0138** (.0060)	.0004 (.0027)	.0105** (.0051)
Importance of research and development staff to business's innovation activities			
Degree to which lack of qualified labour force available anywhere had on hampering business's competitiveness within industry			
Effect lack of labour available locally (within 100 km) had on competitiveness of firm	-.2889 (.1757)	-.0352 (.1183)	-.0729 (.1350)
Importance of local competitors (within 100 km) to business's innovation activities			
Importance of consultants or private institutes to business's innovation activities			
Importance of suppliers (outside 100 km) to business's innovation activities			
Importance of clients and customers to business's innovation activities			
Importance of local suppliers (within 100 km) to business's innovation activities			
Regional dummy variable for Alberta			
Regional dummy variable for Saskatchewan			
Year of establishment of business	.0368** (.0175)	-.0045 (.0088)	.0228* (.0122)
Affiliated with a multinational enterprise			
Impact lack of financing had on competitiveness of business			
Impact new or significantly improved products had on keeping up with competitors			
Impact on business from meeting regulatory requirements of new goods/services			
Impact increased range of goods or services had on business			

*, **, *** denote significance at 10 percent, 5 percent and 1 percent levels respectively.